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ESSENTIA CURRICULUM:
**Curriculum design from a software
engineering approach based on the
SEMAT Essence kernel**

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SEMAT Essence kernel**

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To my loved ones...

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*Tumaco, Nariño, Colombia. July 2019:
Tourist signboard in El Morro Beach and
blue sky*

*Credits: Adobe Stock – camaralucida1 –
https://stock.adobe.com/co/search?k=tumaco&asset_id=422613891*



Abstract

Some curriculum design methods are found by considering a literature review of a century of curriculum design theory; however, documented experiences worldwide indicate curriculum design is done without considering curriculum design methods based on theory. In this vein, this Ph.D. Thesis starts by observing the practices described in curriculum design theory differ from empirical practices, an observation leading to many ways of working. Further, experiences in curriculum design lack documentation, and observable and reliable verification about curriculum design practices from an engineering perspective is lacking. Dealing with such gaps, this Ph.D. Thesis is focused on creating a theoretical foundation for curriculum design—initially focused on computing-related academic programs—from a software engineering approach by using the Software Engineering Method and Theory (SEMAT) Essence kernel. Thus, we establish *ESSENTIA CURRICULUM* in this work. To this end, a linguistic corpus is constructed based on a literature review and contributions from a community of 226 professors with experience in curriculum design worldwide. First, the work focuses on eliciting common practices. Second, the terminology is unified. Third, we propose modifications to the SEMAT Essence kernel for establishing *EC-Nucleus* as the core of *ESSENTIA CURRICULUM*, which is the basis of a language specification easy to understand, and context-free. Thus, *EC-Nucleus* can be applied beyond computing-related academic programs. *ESSENTIA CURRICULUM* is based on computational linguistics analysis of the linguistic corpus, which allows for the identification of common practices and, consequently, the unification of the terminology to support curriculum design endeavors. Ten common practices are represented in *ESSENTIA CURRICULUM*. Such practices and some curriculum design representations proposed by the community constitute a growing library of practices called *EC-Bibliotheca*, which is available online. Finally, the proposal is validated in an academic scenario with favorable results by following the IEEE 1012-2016 standard. The *ESSENTIA CURRICULUM* has the basis for creating specialized computing solutions working on natural language processing in future scenarios due to its definition as a system, theory, method, and model.

Keywords: Curriculum, design, Computational, linguistics, SEMAT, Essence, kernel

***ESSENTIA CURRICULUM*: Diseño curricular a partir de un enfoque de ingeniería de software basado en el núcleo de SEMAT Essence**

Resumen:

Algunos métodos de diseño curricular fueron encontrados al considerar una revisión de la literatura de un siglo de teoría del diseño curricular; sin embargo, experiencias documentadas en todo el mundo indican que el diseño curricular se realiza sin considerar tales métodos de diseño curricular basados en la teoría. En este sentido, esta tesis doctoral comienza observando que las prácticas descritas en la teoría del diseño curricular difieren de las prácticas empíricas, una observación que conduce a muchas formas de trabajar. Además, las experiencias en el diseño curricular carecen de documentación y una falta de verificación observable y confiable sobre las prácticas de diseño curricular desde una perspectiva de ingeniería. Para abordar estas situaciones, esta tesis doctoral se enfoca en crear una base teórica para el diseño curricular, inicialmente orientada en programas académicos relacionados con la computación, desde un enfoque de ingeniería de software utilizando el núcleo de SEMAT Essence. Así, se establece *ESSENTIA CURRICULUM* en este trabajo. Para ello, se construye un corpus lingüístico basado en la revisión de la literatura y contribuciones de una comunidad de 226 profesores con experiencia en diseño curricular a nivel mundial. En primer lugar, el trabajo se centra en educir prácticas comunes. En segundo lugar, se busca la unificación de terminología. En tercer lugar, proponemos modificaciones al núcleo de SEMAT Essence para establecer *EC-Nucleus* como el núcleo de *ESSENTIA CURRICULUM*, que es la base de una especificación de lenguaje fácil de entender y libre de contexto. Por tanto, *EC-Nucleus* se puede aplicar más allá de los programas académicos relacionados con la informática. *ESSENTIA CURRICULUM* se basa en el análisis de lingüística computacional del corpus lingüístico, que permite la identificación de prácticas comunes y, en consecuencia, la unificación de la terminología para apoyar los esfuerzos de diseño curricular. Diez prácticas comunes están representadas en *ESSENTIA CURRICULUM*. Estas prácticas y algunas representaciones de diseño curricular propuestas por la comunidad constituyen una creciente biblioteca de prácticas llamada *EC-Bibliotheca*, que está disponible en línea. Finalmente, la propuesta se valida en un escenario académico con resultados favorables siguiendo el estándar IEEE 1012-2016. *ESSENTIA CURRICULUM* tiene la base para crear soluciones computacionales especializadas que trabajen el procesamiento del lenguaje natural en escenarios futuros debido a su definición como sistema, teoría, método y modelo.

Palabras clave: Currículo, diseño, computacional, lingüística, SEMAT, Essence, núcleo

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Introduction

The curriculum design process has significantly evolved over history, with various methods proposed based on the literature review of curriculum design theory since Kilpatrick (1918) to Ornstein and Hunkins (2018). Such methods—grounded in theoretical frameworks—include structured approaches to curriculum design, aiming to enhance the quality of education. However, some documented experiences in curriculum design worldwide have been developed without applying such theoretically proposed methods. Disconnection between theory and practice raises questions about the practicality of such methods and underscores the need for further research for bridging this gap (OECD, 2020).

Our analysis reveals some divergence between the practices described in curriculum design theory and those employed empirically. This discrepancy has resulted in different working methods and ways of graphically representing curriculum designs. Concurrently, there is a lack of documentation of such empirical experiences in curriculum design, which hampers the sharing and replication of knowledge in this regard. Further, there is a need for observable and reliable verification of curriculum design practices from an engineering perspective for evaluating the efficacy and quality of such methods.

In response to the observed heterogeneity in curriculum design practices and representations, this Ph.D. Thesis is focused on establishing a theoretical foundation for curriculum design, initially targeting computing-related academic programs with a software engineering approach by using the Software Engineering Method and Theory—SEMAT—Essence kernel (OMG, 2018), leading to the creation of *ESSENTIA CURRICULUM*. To achieve this, a linguistic corpus is constructed, drawing from both a comprehensive literature review and the contributions of a community of 226 professors worldwide with experience in curriculum design, with the primary aim of eliciting common practices. Following this, we start a process of terminology unification, leading to proposed modifications to the SEMAT Essence kernel, which resulted in the formation of the kernel

called *EC-Nucleus*. Serving as the core of *ESSENTIA CURRICULUM*, *EC-Nucleus* includes the elements for a language specification easy to understand and context-free, enabling its application beyond computing-related academic programs.

ESSENTIA CURRICULUM, a novel approach to curriculum design, is grounded in the computational linguistics analysis of a linguistic corpus, enabling the identification of common practices and the unification of terminology for supporting curriculum design endeavors. The *ESSENTIA CURRICULUM* method is represented by 10 common practices identified with the analysis, which serve as the foundation for this approach. The 10 foundational practices and the curriculum design representations proposed by the community constitute a growing library of practices called *EC-Bibliotheca*. *EC-Bibliotheca*, available online, is a resource for educators, curriculum designers, and practitioners for easing the sharing and adoption of effective curriculum design practices based on common ground.

ESSENTIA CURRICULUM is a consistent approach to curriculum design we validate in an academic scenario with favorable results following the IEEE 1012-2016 standard (IEEE, 2016). This validation process underscores the reliability and effectiveness of *ESSENTIA CURRICULUM*, reinforcing its usefulness in the academic community belonging to the Ph.D. Program in Educational Sciences at the University of Nariño. In this academic scenario, 10 Ph.D. students participate in the validation process. Furthermore, *ESSENTIA CURRICULUM* lays the groundwork for developing specialized computing solutions leveraging natural language processing (NLP) in future scenarios. This potential stems from its comprehensive definition as a system, a theory, a method, and a model, making it a tool for advancing curriculum design practices.

This Ph.D. Thesis is organized into eight sections. The general aspects of the research are covered in Section 2. In Section 3 we present the literature review. The problem statement is defined in Section 4. Section 5 includes the theoretical foundations and methodological aspects. *ESSENTIA CURRICULUM* is proposed as a solution in Section 6. In Section 7, the proposal is verified and validated based on the IEEE 1012-2016 standard (IEEE, 2016). The last section includes the conclusions, main contributions, and suggestions for future work.

1. General aspects of the research

1.1 Abstract

Curriculum design has historically oscillated between theoretical constructs and empirical practices, often with notable divergence between the two. This Ph.D. Thesis introduces the *ESSENTIA CURRICULUM*, a novel approach to curriculum design that integrates software engineering principles using the SEMAT Essence kernel. Grounded in a rigorous analysis of a linguistic corpus comprising curriculum design theory of a century, 14 documented experiences, and contributions from 226 global scholars, this method seeks to bridge the gap between theory and practice in curriculum design. By establishing a unified terminology and common practices through the development of the *EC-Nucleus* and *EC-Bibliotheca*, *ESSENTIA CURRICULUM* offers a systematic, context-free framework that extends beyond computing-related academic programs. The framework was validated within the Ph.D. Program in Educational Sciences at the University of Nariño in Pasto, Colombia, demonstrating its efficacy and reliability according to the IEEE 1012-2016 standard. This validation involved 10 Ph.D. students and showcased the potential of *ESSENTIA CURRICULUM* to enhance curriculum design through the application of natural language processing technologies, envisioning interesting future work. This thesis lays foundational work for a consistent and replicable approach to curriculum design, promising to facilitate the sharing and adoption of effective practices within the academic community.

1.2 Justification

Curriculum design within the academic field has often revealed a pronounced disconnection between theoretical frameworks devised by educational scholars and the practical methodologies implemented by educators. This gap manifests in inconsistent outcomes and a lack of a systematic approach to adapting educational practices to meet evolving needs, particularly in fields influenced heavily by rapid technological changes such as

computing and engineering. Many existing curriculum design methods, while theoretically robust, fail to account for the complexities and dynamic nature of modern educational environments, leading to a significant underutilization of potential educational innovations. To address these shortcomings, there is a pressing need for a new approach that harmonizes theory with practice, ensuring that educational designs are both scientifically sound and pragmatically viable. The *ESSENTIA CURRICULUM*, rooted in the principles of software engineering through the SEMAT Essence kernel, emerges as a pivotal response to this challenge. By integrating structured engineering methodologies into the curriculum design process, this approach offers a more precise and replicable framework for curriculum design. This is particularly crucial in computing and related disciplines, where the rapid pace of technological advancements demands curricula that can be swiftly adapted to new knowledge and technologies without sacrificing educational depth or rigor. Despite the seminal idea was working on computing-related academic programs, *ESSENTIA CURRICULUM* can be applied beyond such a scope.

Furthermore, the *ESSENTIA CURRICULUM* enhances the accessibility and transferability of effective curriculum design practices through the creation of *EC-Nucleus* and *EC-Bibliotheca*. These tools not only unify terminology and consolidate best practices but also facilitate the sharing and replication of successful models across different educational contexts and disciplines. The involvement of a global community of educators in the development of this corpus ensures that the *ESSENTIA CURRICULUM* is versatile and inclusive, capable of addressing diverse educational needs and challenges. As such, this approach not only addresses the current deficiencies in curriculum design but also sets a forward-looking standard for educational excellence and adaptability.

1.3 Goals

Main objective:

Establishing *ESSENTIA CURRICULUM*, as a theoretical foundation from a software engineering approach based on the Semat Essence kernel, for curriculum design in computing-related programs.

Specific objectives:

1. Identifying common practices from experiences about curriculum design in computing-related programs around the world.
2. Unifying terminology from the identified experiences to create the common ground of a theoretical foundation in curriculum design.
3. Proposing modifications to the Semat Essence kernel by involving curriculum design affairs in computing-related programs (*EC-Nucleus*).
4. Building a library of practices for curriculum design in computing-related programs by using the *EC-Nucleus* (*EC-Bibliotheca*).
5. Verifying and validating both the *EC-Nucleus* and the *EC-Bibliotheca* by applying IEEE 1012:2016.

1.4 Methodology

Our research employs a mixed-method approach, combining qualitative and quantitative paradigms to enrich the data's depth and reliability. The qualitative aspect of our study enables exploration of complex phenomena within their natural contexts, focusing on understanding the nuanced interpretations and subjective experiences of participants. This approach is complemented by a quasi-experimental design, which involves the controlled introduction of variables to observe their effects without the need for random assignment. This method strikes a balance between experimental rigor and the practical realities of educational settings.

Additionally, the research is guided by the General Method of Theory Building in Applied Disciplines, which provides a structured yet adaptable framework for theory development in real-world applications. This method emphasizes the integration of theory and practice and supports the iterative refinement of theories based on continuous observations and findings. This approach allows for the development of robust theoretical frameworks that are highly applicable to practical scenarios, effectively bridging the gap between theoretical research and practical implementation.

In this vein, chapter 3 in this document provides more details in terms of the methodology applied in this Ph.D. Thesis.

2. Literature review

A systematic literature review is a methodical and comprehensive approach to reviewing research literature. It aims to collect, critically evaluate, and synthesize all relevant studies on a specific topic, question, or area of interest (Higgins & Green, 2011). Key steps typically involved in conducting a systematic literature review are listed as follows:

1. **Formulate a Research Question:** Clearly define the question or problem that the review aims to address. This step includes specifying the criteria for selecting studies, such as the types of studies, participants, interventions, and outcomes.
2. **Develop a Protocol:** Establish a plan or protocol that outlines the methods for conducting the review. This includes search strategies, databases to be searched, inclusion and exclusion criteria, and methods for data extraction and synthesis.
3. **Literature Search:** Conduct a thorough search using multiple databases and sources to find as much relevant literature as possible. The goal is to minimize bias by ensuring a comprehensive search.
4. **Screen and Select Studies:** Apply the inclusion and exclusion criteria to screen the search results and select studies that will be included in the review.
5. **Data Extraction:** Extract relevant data from the included studies. This data often includes study characteristics, methods, participants, interventions, outcomes, and results.
6. **Quality Assessment:** Assess the quality of the included studies. This helps to determine the strength of the evidence provided by the studies.
7. **Data Synthesis:** Synthesize the data from the included studies. This could involve qualitative summary, meta-analysis (if the data are quantitative and sufficiently homogenous), or other forms of synthesis depending on the nature of the evidence.
8. **Report and Disseminate Findings:** Write up the findings in a structured report, discussing the implications of the findings, limitations of the review, and recommendations for future research.

Systematic literature reviews are valuable in evidence-based practices because they provide a robust summary of the available evidence on a given topic, allowing for informed decision-making. They are commonly used in healthcare, social sciences, and environmental studies, among other fields.

According to the above, we established a Systematic Literature Review protocol based on (Zapata & baron, 2016) which involves the aspects mentioned above. Figure 2-1 depicts the Systematic Literature Review used in this research.

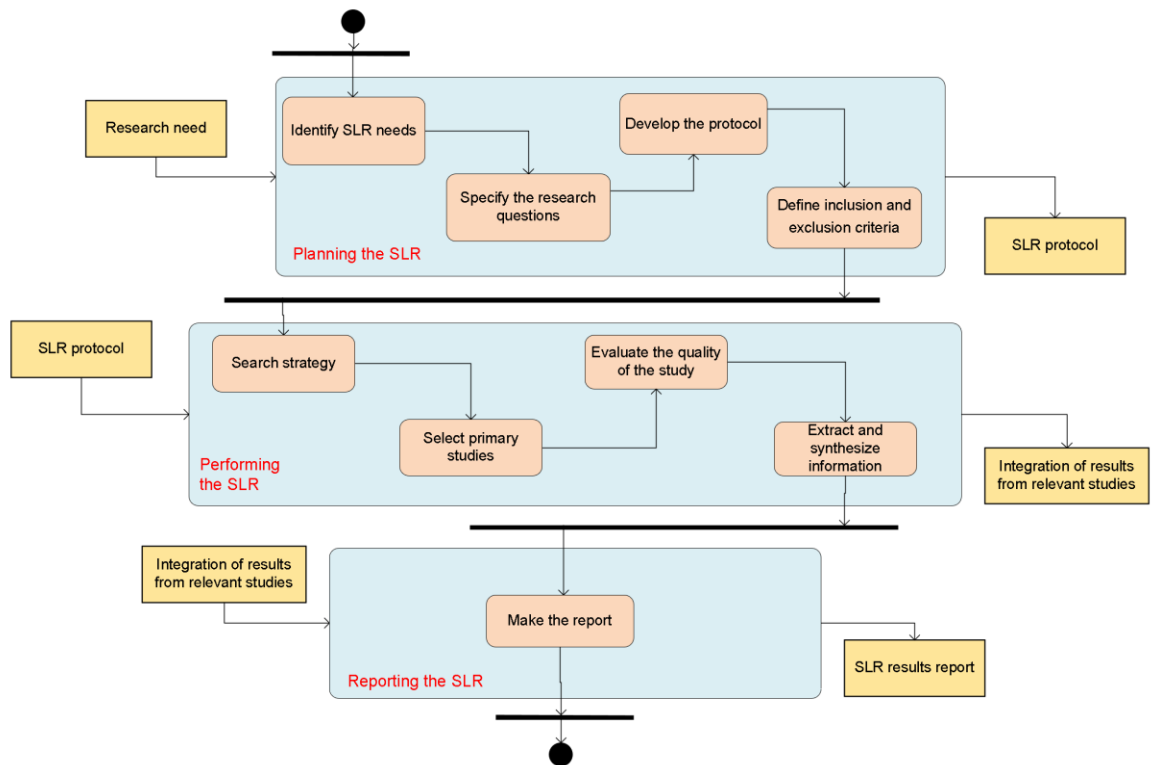


Figure 2-1: Systematic Literature Review protocol based on (Zapata & Baron, 2016)

The need to perform a systematic literature review stems from the academic community's requirement to aggregate all pertinent data thoroughly and fairly regarding a particular subject. By undertaking a systematic review on methods of curriculum design, researchers can gather, scrutinize, and summarize the significant literature associated with this area. The findings will provide a credible basis for dissemination within the scholarly community.

2.1.2. Specify research questions

The development of research questions is a key step in the systematic literature review process. These questions direct the initial search for studies and the subsequent information extraction and synthesis needed to respond to them.

For this systematic review, the following two research questions have been formulated:

RQ1. Which methods are utilized in designing curricula?

RQ2. What elements are incorporated into such methods?

The protocol should outline the methods, techniques, and tools necessary to ensure a comprehensive and unbiased systematic literature review. To construct this SLR, the following procedures are employed: (i) pinpointing adequate and pertinent sources of studies for the research; (ii) creating search strings to locate possible studies for inclusion in the review; (iii) establishing criteria for inclusion and exclusion to filter studies pertinent to the research.

The main purpose of inclusion criteria is to select relevant literature for the research; in this sense, the criteria for this review are shown below:

INCLUSION CRITERIA

Time window (1918 – 2018)

Studies that refer to methods for curriculum design

Title of the document related to curriculum theory.

EXCLUSION CRITERIA

Research in a language other than English is not considered.

Duplicate articles

Literature reviews or mappings are not considered.

The protocol dictates the application of search strings for this study. For the systematic literature review concerning technologies used in energy transactions, it is defined as follows:

("curriculum design" OR "curriculum theory") AND ("method").

On applying our protocol, we work with three sources as depicted in Figure 2-2, obtaining the result.

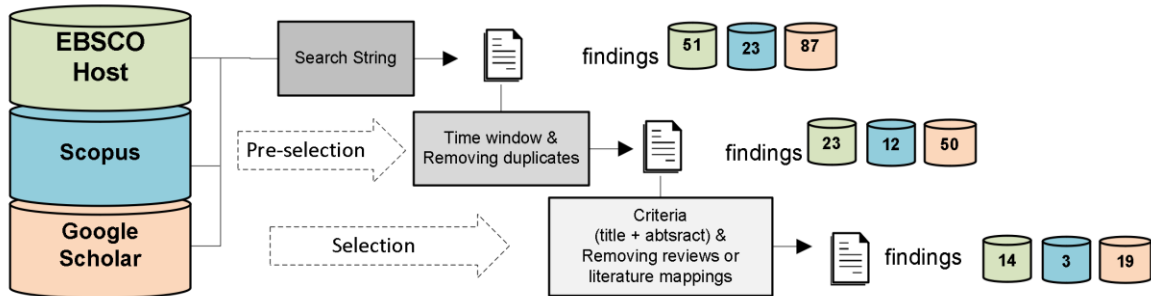


Figure 2-2: Systematic literature review, sources, criteria, and findings.

Curriculum design is deliberate curriculum organization within educational institutions or for specific educational programs. At its core, curriculum design aims to facilitate learning by providing a structured, coherent framework that aligns content, teaching methodologies, and assessment practices. The central objective is to ensure that learners acquire the necessary knowledge, skills, and attitudes to succeed in their desired pursuits, whether in further education, careers, or life (Munna & Kalam, 2021).

Twenty-two curriculum design contributions have been identified in educational affairs (3 from Scopus and 19 from Google Scholar). A timeline of a century of curriculum design theory is depicted in Figure 2-3.

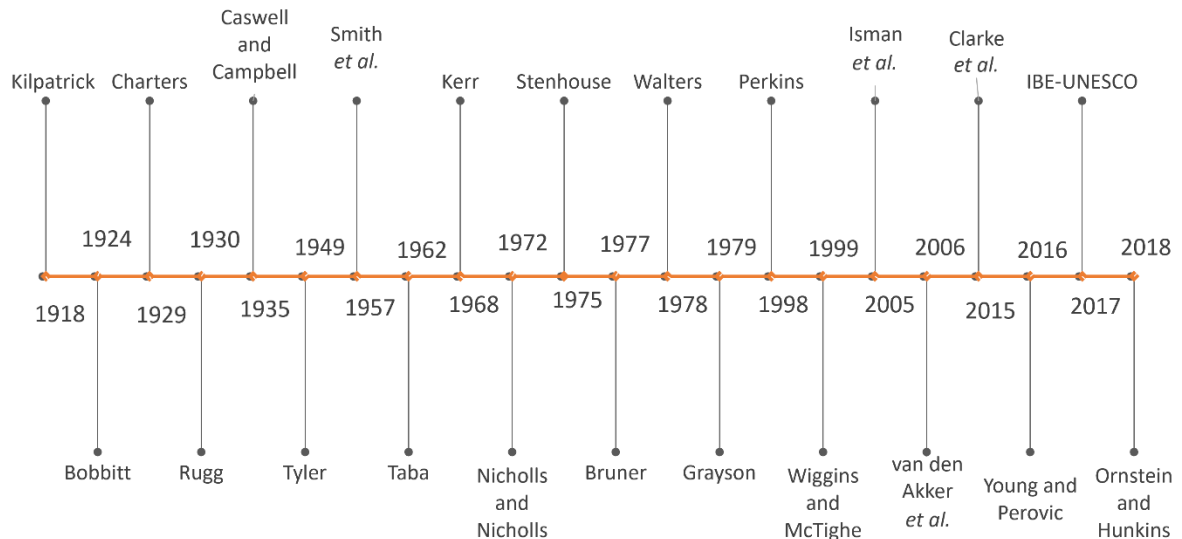


Figure 2-3: Timeline of a century of curriculum design theory.

According to the above, 22 proposals from curriculum design theory are found. A curriculum comprises a theory—or theories—and a method—or methods—and a method is a set of interrelated practices. These scholars proposed theories or used the pre-established ones to describe the method finally; thus, when these actions are being executed, a curriculum design arises, as depicted in Figure 2-4.

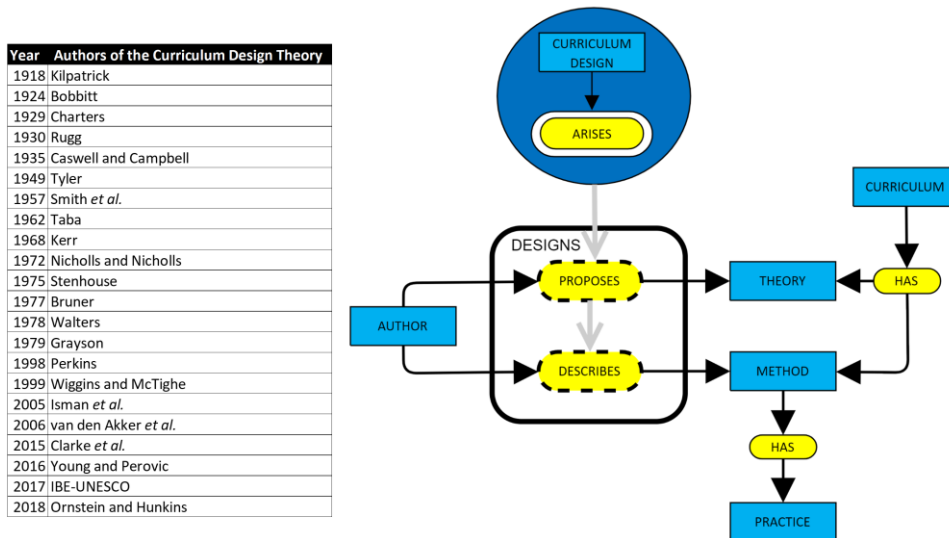


Figure 2-4: Authors included a century of curriculum design theory.

Considering the curriculum design theory in this literature review, some methods for curriculum design have been identified from such contributions. Despite the existence of curriculum design methods, curriculum designers are autonomous when adapting their own strategies in matters of curriculum design (Karakuş, 2021). Given this autonomy, some curriculum designers begin their work with different conceptions of the meaning or essence of the curriculum concept. For instance, some of them focus their designs only on the structure of content, others work with content and teaching–learning strategies, and so on (Ali, 2018).

Curriculum design depends on the type of curriculum product expected from the design. Hence, the concept of a curriculum product is becoming more relevant. According to van den Akker *et al.* (2006), some curriculum products are related to curriculum design, and such products depend on the application level. Examples of curriculum products are depicted in Table 1-1. Further, van den Akker *et al.* (2006) introduced the concept of educational aspects to be considered in curriculum design. Such educational aspects are

strictly related to curriculum products. Educational aspects are essential components of the rationale for curriculum design.

Every single educational aspect matters in a curriculum design endeavor. To consider educational aspects, curriculum designers should raise some questions focused on the students: Why are they learning? (i.e., rationale), Which learning goals are being targeted? (i.e., aims and objectives), What are they learning? (i.e., content), How are they learning? (i.e., learning activities), How is the teacher facilitating their learning? (i.e., teacher's role), What are they learning with? (i.e., materials and resources), Whom are they learning with? (i.e., grouping), Where are they learning? (i.e., location), When are they learning? (i.e., time), and How is their learning assessed? (i.e., assessment). These questions and aspects can be expressed as a spider web regarding curriculum design, as shown in Figure 2-5.

Table 2-1: Curriculum levels and curriculum products (van den Akker *et al.*, 2006).

Level	Description	Examples of curriculum products
SUPRA	International	• Common European Framework of References for Languages
MACRO	System, national	• Core objectives, attainment levels • Examination programs
MESO	School, institute	• School program • Educational program
MICRO	Classroom, teacher	• Teaching plan, instructional materials • Module course • Textbooks
NANO	Pupil, individual	• Personal plan for learning • Individual course of learning

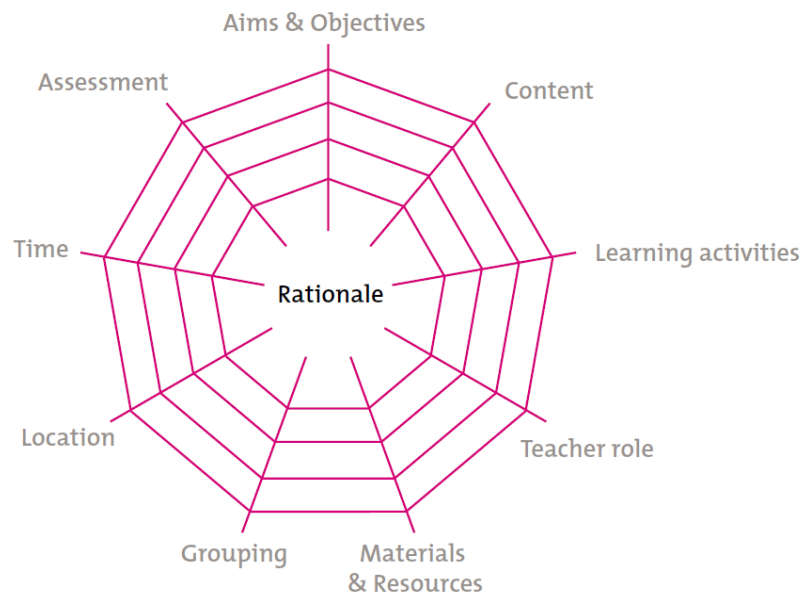


Figure 2-5: The curriculum spider web (van den Akker *et al.*, 2006).

In this vein, curriculum design is more than an activity to create a course structure for a program. Several educational aspects, such as pedagogical models, teaching–learning strategies, and assessment activities, should be considered in addition to the specification of a course structure (Navarro *et al.*, 2016). Despite the existence of curriculum design methods, the following 14 chronologically ordered (from EBSCO host), documented experiences demonstrate that designers use their own criteria, ignoring such methods and dealing with only a few educational aspects.

Desai and von der Embse (2001) proposed a synergistic interaction model depicted in Figure 2-6. In their proposal, the educational institution interacts with business organizations to define the main topics to consider in the curriculum. The authors used Venn diagrams and involved only one educational aspect related to content and its intersections in the fields of knowledge.

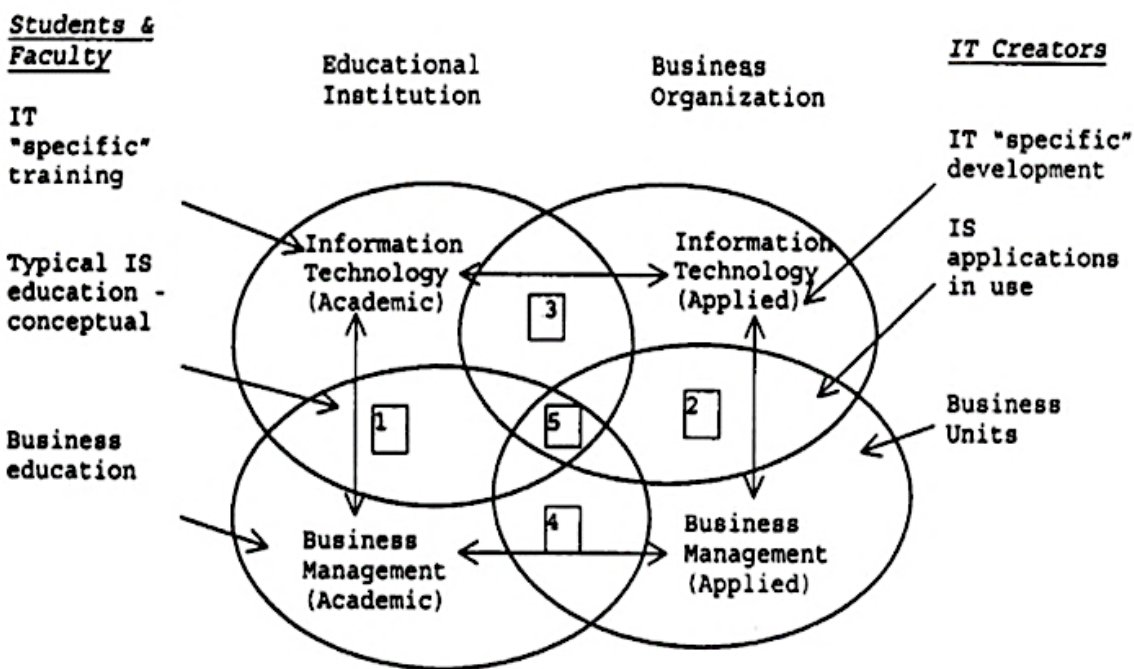


Figure 2-6: Curriculum design proposed by Desai and von der Embse (2001).

An 8-step curriculum development template is proposed for a general structure of courses with prerequisites by using sequential blocks. According to Burkett (2002), curriculum design is based on two educational aspects: the method of construction and the sequential representation of the courses in the program, as depicted in Figure 2-7.

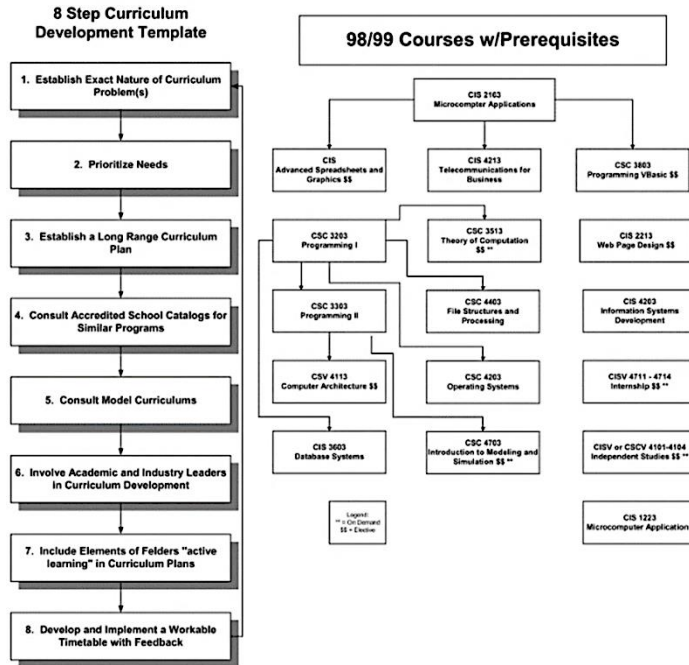


Figure 2-7: Curriculum design proposed by Burkett (2002).

Focusing on content, another way to represent a curriculum is based on a flow path diagram. Here, students advance their educational processes by following the path (Ehie, 2002). The curriculum proposal includes contents and course sequences, as Figure 2-8 depicts.

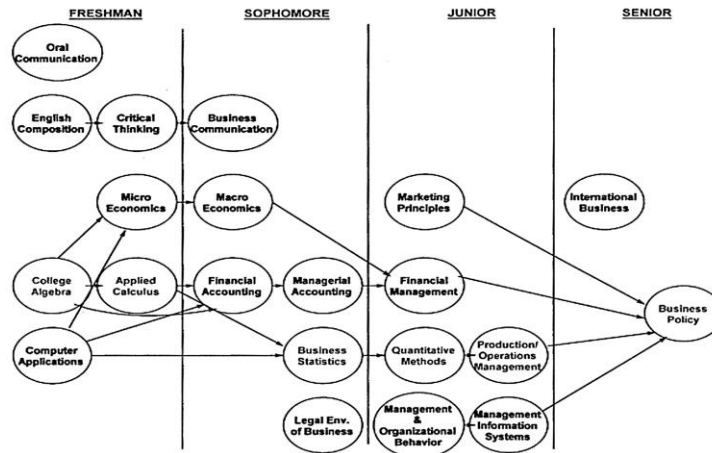


Figure 2-8: Curriculum design proposed by Ehie (2002).

A block diagram can be useful in defining a course structure, and a curriculum has been proposed using block diagrams (Golden & Matos, 2006). The proposal depicted in Figure 2-9 uses only the course structure as an educational aspect.

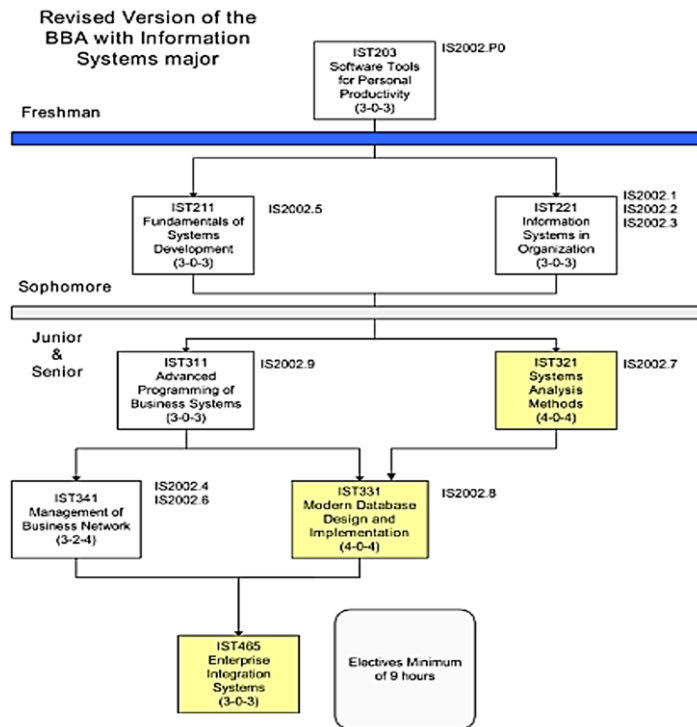


Figure 2-9: Curriculum design proposed by Golden and Matos (2006).

Another proposal is a layer-based architecture with block representation, as depicted in Figure 2-10 (Ding *et al.*, 2011). This includes one educational aspect related to course schema content.

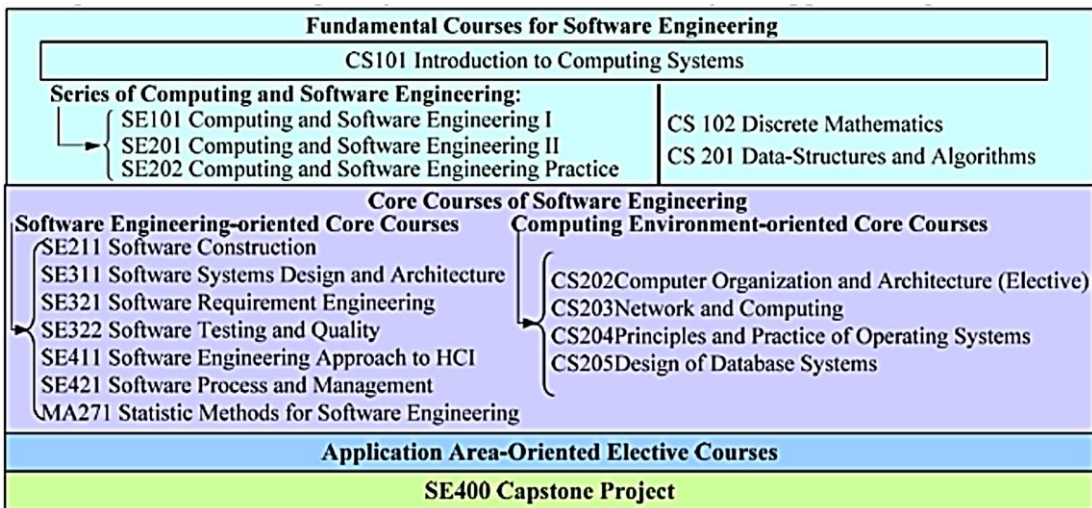


Figure 2-10: Curriculum design proposed by Ding *et al.* (2011).

A proposal for standardizing a new undergraduate curriculum for an information technology degree was conceived using a progress graph representing the course structure, as

depicted in Figure 2-11. This proposal is based on nodes as courses and arrows as the sequential paths among them, and only the course structure is used to represent an educational aspect (Wang *et al.*, 2011).

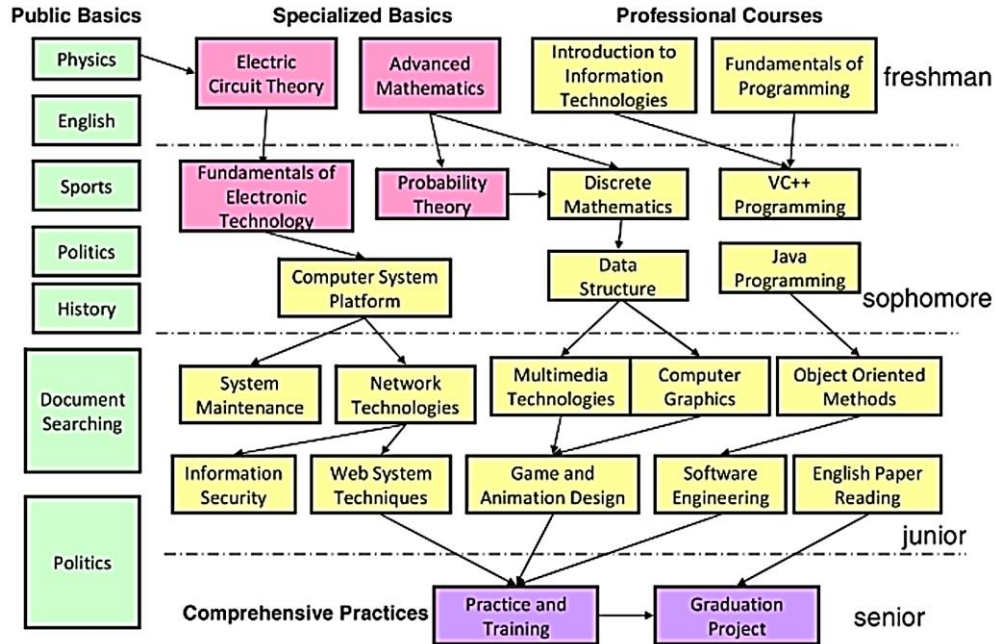


Figure 2-11: Curriculum design proposed by Wang *et al.* (2011).

A project-based curriculum has been defined by describing a sequence of courses, as depicted in Figure 2-12 (Martínez & Luna, 2012).

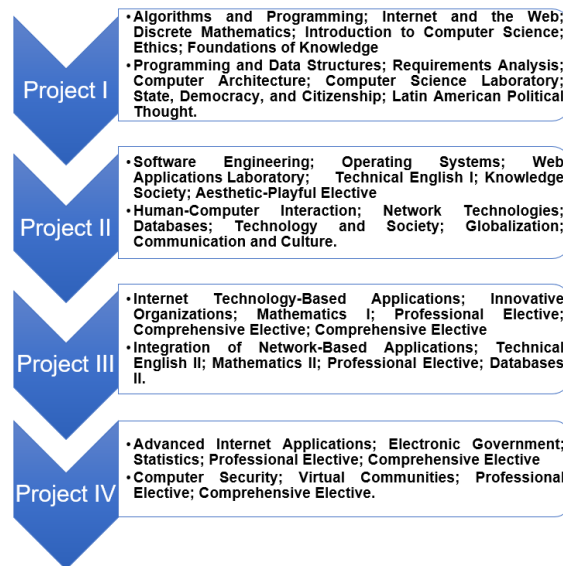


Figure 2-12: Curriculum design translated from Martínez and Luna (2012).

A frequency analysis involves a range of distance oscillations between 0 and 1.4 (Nakayama, 2015). The course structure is the educational aspect used in the proposal, as depicted in Figure 2-13. The term “distance” measures similarities among bodies of knowledge on the covered topics.

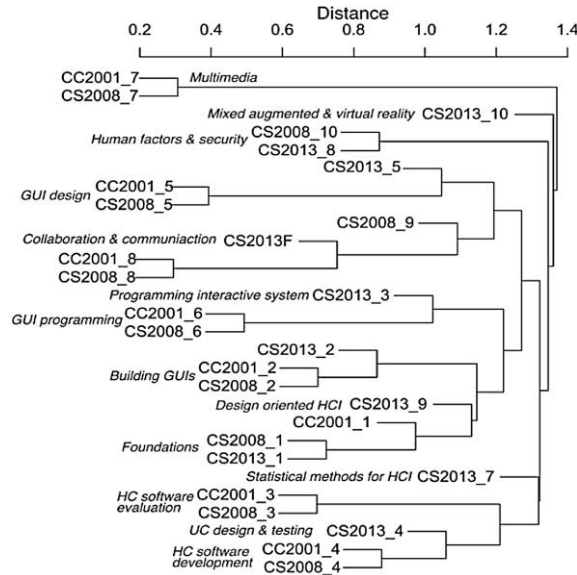


Figure 2-13: Curriculum design proposed by Nakayama (2015).

Another design is a curriculum based on a graph chart with connected nodes and tabular descriptions, as depicted in Figure 2-14 (Cuadros-Vargas *et al.*, 2013). Here, only the course structure is the educational aspect considered in the graphical representation of the sequential path.

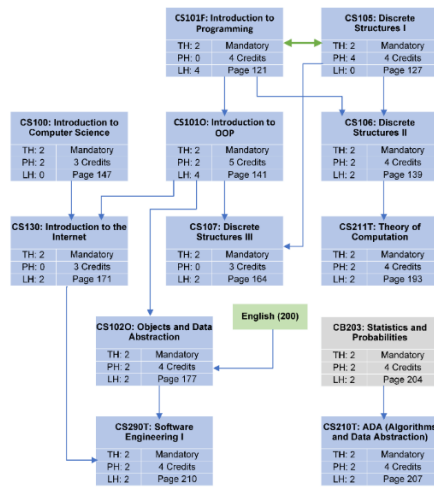


Figure 2-14: Excerpt of the curriculum design translated from Cuadros-Vargas *et al.* (2013).

A block-based diagram for course structures has been proposed. Blocks grouped by components represent the course structure in this design (Villapol *et al.*, 2013), which is the only educational aspect, as depicted in Figure 2-15.

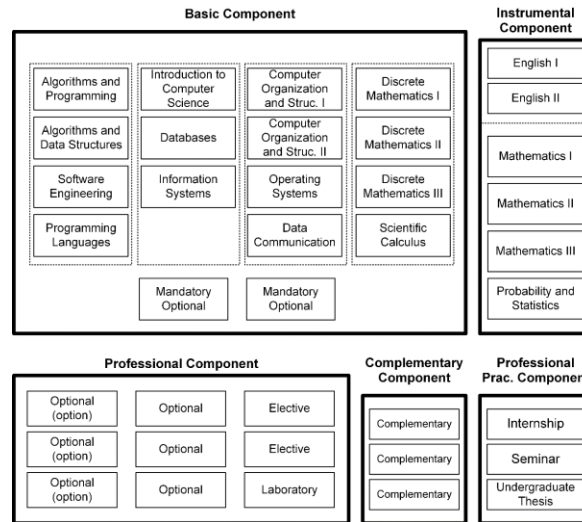


Figure 2-15: Curriculum design translated from Villapol *et al.* (2013).

Another way to represent content in curriculum design includes a matrix of representative collections of technologies and innovation stages (Fichman *et al.*, 2014). This way of designing a curriculum helps formulate courses for the program. The design includes a way of distributing the main topics into the matrix. The proposal defines the course structure and educational purposes. Thus, the authors integrated a matrix of contents and educational purposes as the basis for formulating academic courses, as depicted in Figure 2-16.

General Technology Domains	- Discovery -	- Development -	- Diffusion -	- Impact-
Architecture/ Infrastructure	"Maker" movement/desktop mfg	Mobile and Cloud Computing		E-business
Enterprise Platforms		Product Lifecycle Management	Customer Relationship Management	Enterprise Resource Planning
Data Management		Content Management Technologies		Datawarehouse Technologies
Analysis and Decision Support	Real-time Question Answering Systems	Business Analytics, "Big Data"		
Communication, Collaboration and Digital Media	Experiential Computing	Social Media	Enterprise Mobility	Virtual Teams

Figure 2-16: Curriculum design proposed by Fichman *et al.* (2014).

Block diagrams and semiformal UML notation (i.e., activity diagrams) have been proposed to represent curriculum design (Espinosa *et al.*, 2016). Despite the use of several representations in this design, only two educational aspects are considered: content and their sequential path, as depicted in Figure 2-17.

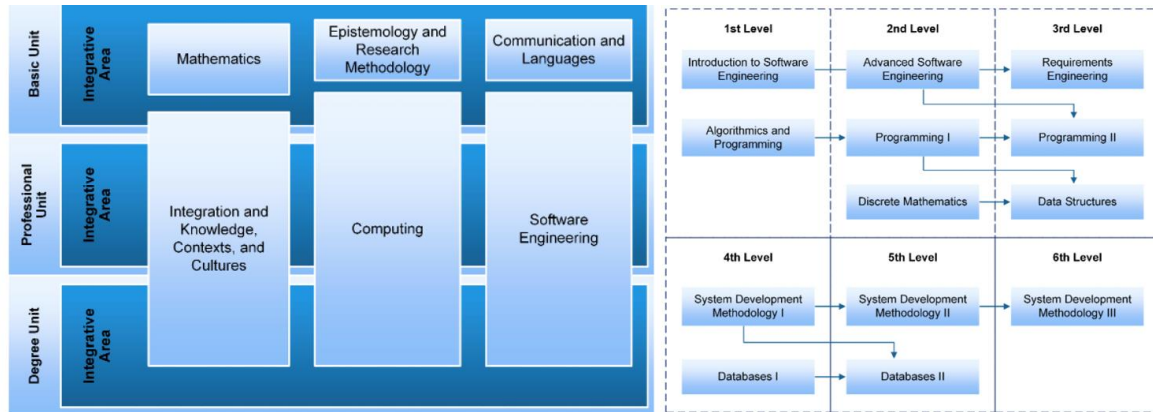


Figure 2-17: Curriculum design adapted from Espinosa *et al.* (2016).

A curriculum structure based on a timeline is another way of constructing a curriculum design (Ristov *et al.*, 2016), with courses and the inner information about assessment, as depicted in Figure 2-18. Two educational aspects are included: course structure and assessment criteria.

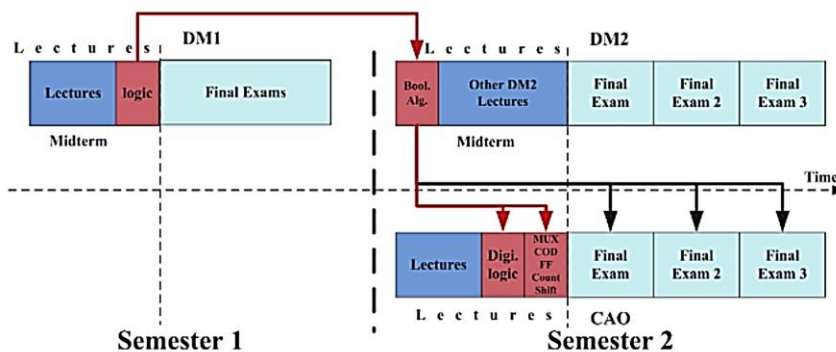


Figure 2-18: Curriculum design proposed by Ristov *et al.* (2016).

The experience of curriculum design for the software industry involves a vision of systemic thinking (Ontiveros & Antolinez, 2013). Methodological design is prioritized rather than the design of the curriculum itself. The foundations of the design are involved as an educational aspect, as depicted in Figure 2-19.

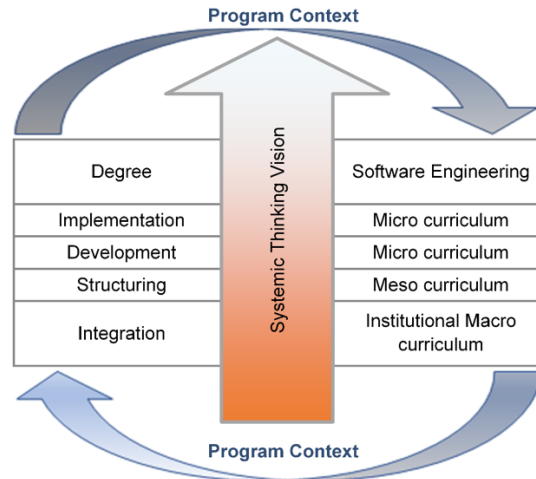
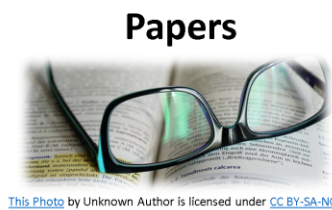


Figure 2-19: Curriculum design translated from Ontiveros and Antolinez (2013).

This literature review clearly provides evidence of heterogeneous practices and representations, with the use of diverse concepts and diverse strategies in curriculum design and graphically representing the curriculum designs. In the end, these 14 documented experiences described above demonstrate that despite the existence of established methods for curriculum design from theory, in practice these methods are not used, which leads to heterogeneous designs and representations, and they do not consider all the aspects proposed by van den Akker's (2003). Figure 2-20 shows the list of documented experiences in this regard.

Some Curriculum Design graphic representations



Year	Authors
2001	Desai & vor der Embse
2002	Burkett
2002	Ehie
2006	Golden & Matos
2011	Ding <i>et al.</i>
2011	Wang <i>et al.</i>
2012	Martinez & Luna
2013	Cuadros-Vargas <i>et al.</i>
2013	Ontiveros & Antolinez
2013	Villapol <i>et al.</i>
2014	Fichman <i>et al.</i>
2015	Nakayama
2016	Espinosa <i>et al.</i>
2016	Ristov <i>et al.</i>

Source: The Authors

Figure 2-20: List of some curriculum design graphic representations.

3. Problem statement

According to the findings of the literature review, the practices described in curriculum design theory differ from empirical practices. This indicates a gap between the theory and the practices of designers. This notion is represented in a pre-conceptual schema depicted in Figure 2-1.

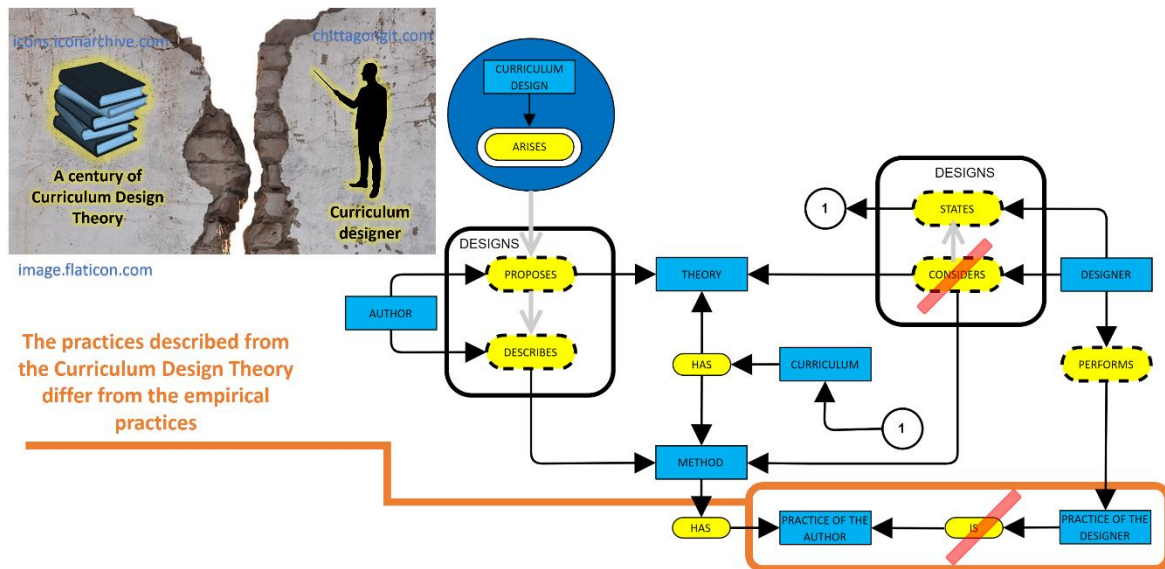


Figure 3-1: The gap between what theory says and what designers really do.

Designers often state their curriculums, yet they frequently overlook the curriculum design theories suggested by scholars. It is notorious that the methods they employ in curriculum design in these works differ significantly from the theoretical practices outlined by these experts. This discrepancy highlights various challenges in the current curriculum design landscape. One major issue is the dominance of individualistic approaches over a more systematic, engineering-based methodology, which complicates the sharing of essential

insights among different practices. Additionally, there is a notable lack of documentation of curriculum design experiences, posing the risk of losing valuable knowledge in this field. Furthermore, tangible and credible methods are absent from an engineering viewpoint to verify curriculum design practices. Consequently, curriculum designers often work in isolation, as Figure 3-2 illustrates.



Figure 3-2: Current perspective of curriculum designers. Source: pbs.twimg.com

4. Theoretical framework

This chapter is divided into seven sections. The first describes the main theory underlying this Ph.D. Thesis: the SEMAT Essence. The second section lists examples of applying the SEMAT Essence in educational settings. The third section describes a technique for textual analysis and knowledge representation. The fourth section deals with a general method for building a theoretical foundation. The fifth section describes aspects related to terminology unification. The sixth section includes information on system validation and verification to establish a scenario of verifiable validity for this Ph.D. Thesis. The last section includes additional material with Action Design Research, SEMAT Essence-related research, and Delphi data collection as a formal description of methods.

4.1 SEMAT Essence

Regarding standardization, the Object Management Group (OMG) is a global consortium with open membership, operating as a non-profit organization dedicated to technology standards. OMG has issued a standard that outlines the core framework and language used for methods and practices in software engineering, as advocated by the SEMAT community. This foundational framework and language are collectively called SEMAT Essence (OMG, 2018).

The SEMAT Essence standard was developed in 2009 by Ivar Jacobson, Bertrand Meyer, and Richard Soley. It originated from a proposal that addressed the challenge posed by the vast array of existing methods and theories for the design and development of software applications, which complicates the sharing of knowledge and experiences (Jacobson *et al.*, 2013). SEMAT Essence is characterized by its scalability, flexibility, and user-friendliness. It provides a framework for individuals to articulate their current and future methods and practices and how these can be evaluated and measured (OMG, 2018).

SEMAT Essence encompasses three key areas of concern, each targeting distinct elements of software engineering: customer, solution, and endeavor. Within software engineering, a concept known as the abstract-level progress health attribute (ALPHA), as defined by SEMAT Essence, symbolizes the various elements individuals engage within their work. The ALPHAs and their interconnections are illustrated in Figure 3-1.

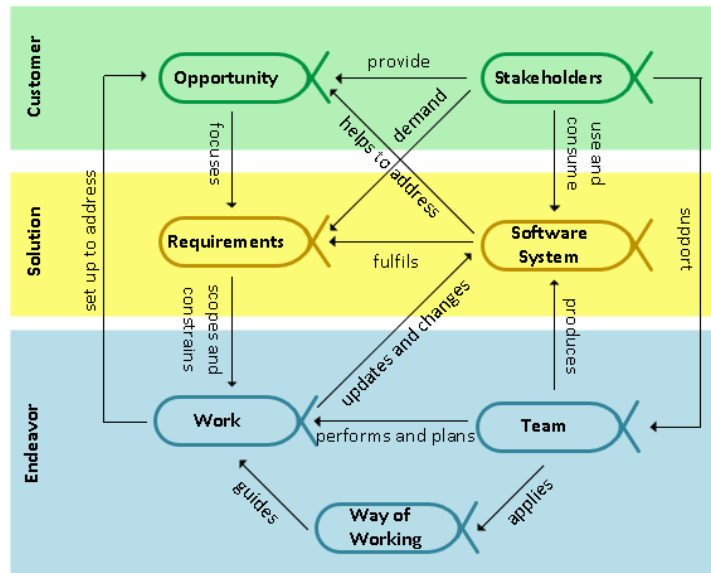


Figure 4-1: Areas of concern and ALPHAs in SEMAT Essence (OMG, 2018).

Activity spaces in SEMAT Essence are collections of activities centered around a particular theme. These activity spaces are arranged according to their area of concern within SEMAT Essence, and this organizational structure is visually represented in Figure 3-2.

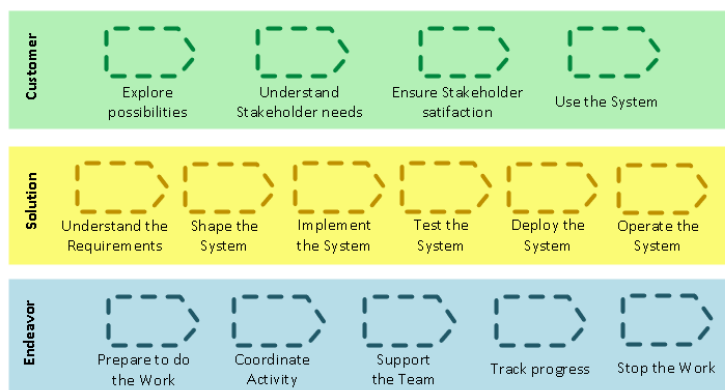


Figure 4-2: Activity Spaces in the SEMAT Essence (OMG, 2018).

Functionally, SEMAT Essence incorporates a range of competencies essential for those utilizing it. These competencies are distributed across the various areas of concern and are graphically presented in Figure 3-3.

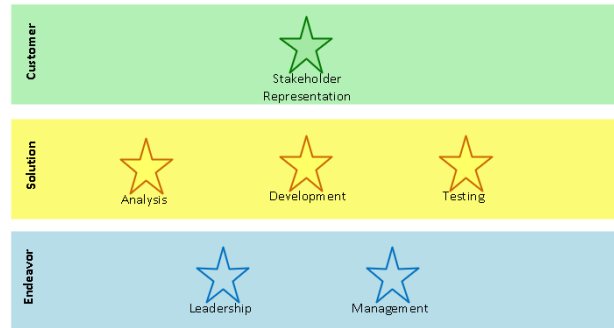


Figure 4-3: Competencies in the SEMAT Essence (OMG, 2018).

Currently, SEMAT Essence represents a groundbreaking effort to establish a fundamental, shared basis for the field of software engineering. Its goal is to enhance the quality of software engineering practices by introducing a uniform kernel—a core set of components applicable to all software development projects. SEMAT Essence is a valuable resource for software professionals, enabling them to comprehend, assess, and refine their working methods. It is not a method or process but a framework for consistently conceptualizing, articulating, and applying various methods and practices. Presently, the emphasis is more on practices than on software engineering methods per se.

4.2 SEMAT Essence in educational scenarios

Although initially designed for software engineering, the foundational aim of the SEMAT Essence, particularly its strategy of deconstructing intricate tasks into basic elements—the “kernel”—renders it suitable for application in areas beyond mere software engineering. Owing to its modular and state-driven design, SEMAT Essence can offer a framework for various other disciplines that necessitate structured processes or methods. This adaptability is especially applicable in the context of educational environments.

It is worth noting that while SEMAT Essence offers a promising framework, adapting it to domains outside of software engineering would require a deep understanding of the new domain and significant customization. The power of SEMAT Essence lies in its modular

and adaptable design, which allows for such customization while maintaining a consistent underlying structure.

In both academic and industrial circles, experts can investigate the application of SEMAT Essence across diverse fields. When contemplating its use in a particular domain, examining recent scholarly papers or case studies is beneficial to gain insight into previous endeavors and their results.

When projects need to be organized using an ALPHA-based structure in software engineering courses, employing SEMAT Essence is a practical approach (Ibargüengoitia & Oktaba, 2014). Ibargüengoitia and Oktaba (2014) delved into the difficulties of creating software engineering courses for undergraduate and master's-level students. They investigated how SEMAT Essence and its annex B *Kuali-Beh* can be used to streamline and diagrammatically convey software engineering concepts and practices. Their work recounts experiences in organizing these courses with the proposed approach. Another scenario for the use of SEMAT Essence is teaching software engineering. Cifuentes, Hernández, and Aponte (2014) shared an initial experience integrating SEMAT and agile methodologies into a software engineering course. The teaching approach equips students with practical skills to address technical and non-technical challenges, such as domain-specific learning and team collaboration. The unique challenges of academic software projects are highlighted, and methods for adapting agile principles to these contexts are proposed. The work details a strategy to incorporate the SEMAT kernel and language into an agile-based course, using kernel ALPHAs as a guiding roadmap from project initiation to conclusion. These ALPHAs also offer instructors a unified framework for assessing and monitoring project progress and health.

Teaching embedded systems is another scenario for applying SEMAT Essence. The rising demand for embedded systems necessitates engineers with specialized expertise. Higher education institutions focus on lectures and labs; however, these methods often fail to foster the necessary technical and social competencies. A unified framework to streamline the teaching and learning process is also lacking. The work proposed by Sánchez *et al.* (2015) introduces a method to represent teaching and learning practices for embedded systems, emphasizing competency development. The approach uses the SEMAT Essence kernel, a universal framework for software engineering practices, and suggests an extension for broader applications. Their work offers a foundational representation of embedded system education practices, detailing essential elements and potential extensions for specificity.

Unification in educational practices can be addressed using the SEMAT Essence. Under the model of propaedeutic cycles, higher education classrooms often comprise a mix of students: those with prior technical or technological training in computer systems, those employed in tech sectors, and those whose only prior education is high school. This creates two distinct profiles: students using the preparatory cycle and “regular” students without prior computer science knowledge. The integration of these cycles has occasionally led to compromised educational quality, especially in systems engineering, when students of varied backgrounds share a classroom. To address this disparity, there is a need for pedagogical strategies that optimally integrate the SEMAT Essence kernel to include diverse students from computing-based programs, ensuring that its full potential is grasped and later applied in professional settings. Focusing on familiar methodologies from their work experience is beneficial for those with prior degrees. Conversely, those without work experience can benefit more from a theoretical approach. Creating shared discussion platforms for all students to exchange experiences and research findings is also recommended (González & Becerra, 2015).

Computer science and software development are integral to many knowledge domains, leading to a surge in optimizing development methods. Agile methodologies, which prioritize individual interactions, functional software, client collaboration, and adaptability, are now implemented in over 90% of related organizations (Gómez *et al.*, 2015). However, challenges persist. Enrollment in computing higher education is declining, as seen in Colombia, where interest in computing programs has decreased, and over half of the enrollees in the past decade have not completed their courses. Moreover, many programs have not transitioned to teaching agile methodologies. The proposal reviews the integration of agile methods in education and explores their implementation as pedagogical tools.

Software engineering integrates technical and vital social competencies, such as communication and leadership, which are essential for successful projects. With the growing demand for software products across various sectors and the need to balance theory and practice in education, the research line of software engineering education has emerged. Although there are various teaching strategies, such as project-based and collaborative learning, they are often described subjectively, challenging educators in content presentation and strategy formulation. Gómez *et al.* (2015) introduce SETMAT—Software Engineering Teaching Methods And Theory—a comprehensive theory for software engineering education. SETMAT, derived from prior experiences, outlines vital

concepts related to software engineering teaching, incorporating expected competencies based on different roles within software development. The theory was validated using practices from two university environments and feedback sessions with educators. SETMAT provides a standardized framework for representing teaching practices, facilitating better comparison and transfer of teaching strategies in software engineering (Gómez, 2018).

4.3 Pre-conceptual schemas

Textual analysis can be done by using pre-conceptual schemas, whose elements are depicted in Figure 4-4. The use of pre-conceptual schemas starts by establishing an analysis from sources such as documentary reviews, questionnaires, and interviews, among others. The analysis is based on computational linguistics techniques (Zapata, 2007).

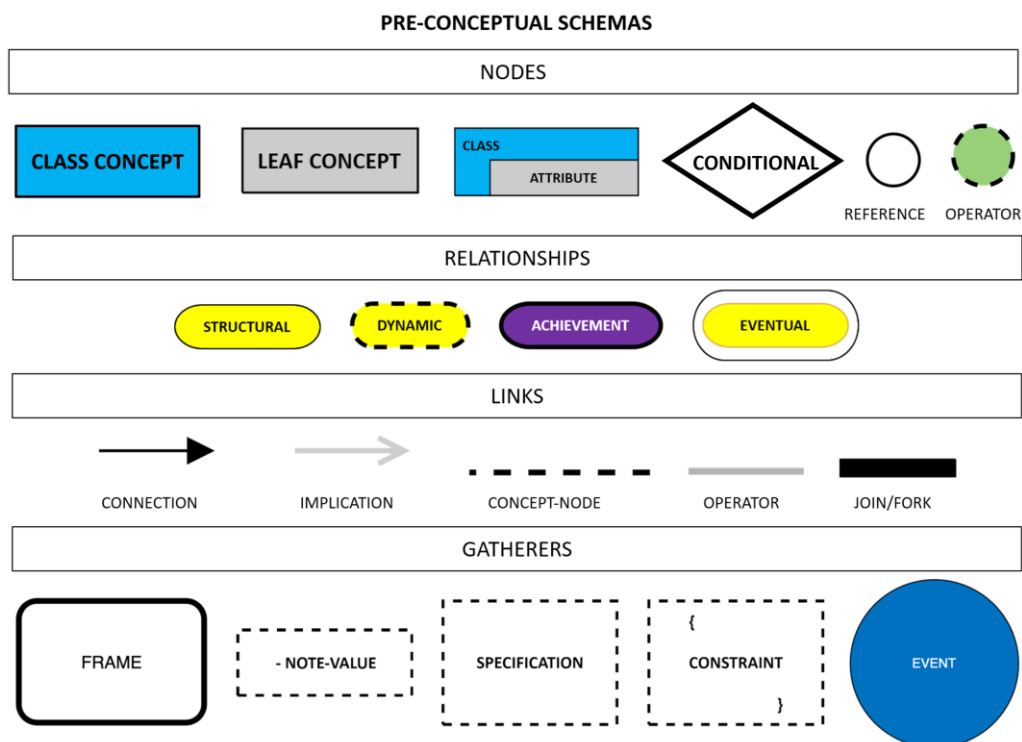


Figure 4-4: Pre-conceptual schema notation based on Noreña (2020).

Pre-conceptual schemas are aimed at graphically representing knowledge by following well-defined semantics. According to Zapata (2007), a pre-conceptual schema is a way of specifying structured ideas by using a controlled language. In addition, pre-conceptual

schemas use a simple notation, are easy to understand, and are adaptable to any domain of knowledge (Zapata *et al.*, 2006). According to the notation, any representation of knowledge can be expressed using pre-conceptual schemas.

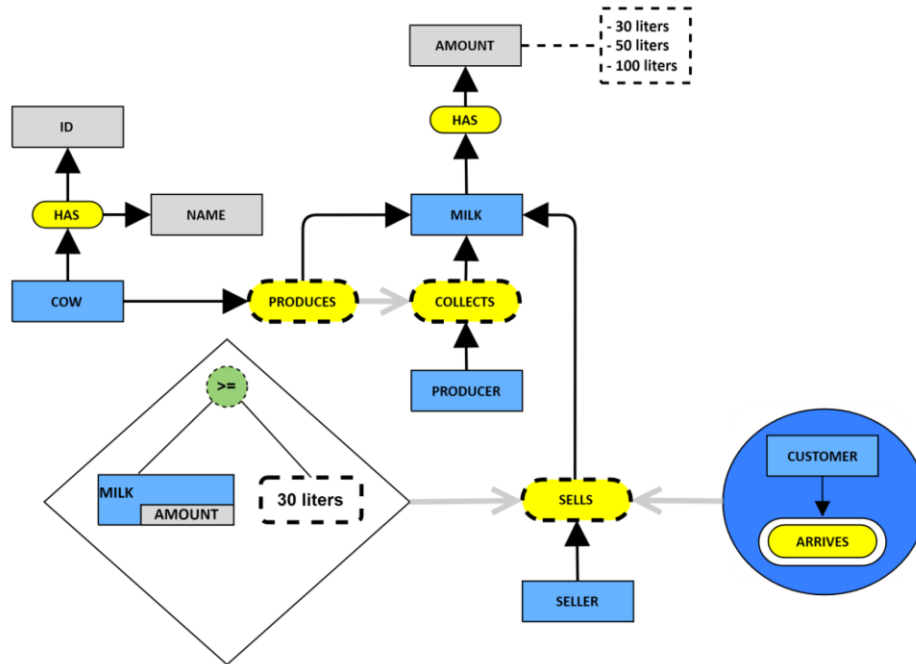


Figure 4-5: Example of pre-conceptual schema, based on Zapata-Tamayo and Zapata-Jaramillo (2018).

Figure 4-5 illustrates four animated figures, termed actors: the producer, the seller, the customer, and the cow. It is important to note that milk production is variable, with quantities typically ranging from 30 to 100 liters. Per the pre-conceptual schema's order, each cow is identified by an ID and a name. Similarly, the producer is responsible for collecting milk, provided that the cow has produced it, highlighting a significant relationship of implication. Additionally, the seller comes into play when a customer appears (triggering an event in the system). Still, there is a limitation in cases in which sales can only occur if the milk quantity requested is 30 liters or more.

All textual analyses of this Ph.D. Thesis have been developed through representations in pre-conceptual schemas. This has made it possible to generate representations of knowledge using a controlled language.

4.4 Building a theoretical foundation

The overall approach to developing theories in applied fields enables the integration of theoretical concepts and practical applications in intricate scenarios. The initiation of theory construction can emerge from theoretical innovations or practical experiences. The key significance of this comprehensive method lies in its capacity to consistently incorporate diverse origins into the evolution of theories (Swanson & Chermack, 2013). This theoretical model is depicted in Figure 4-6.

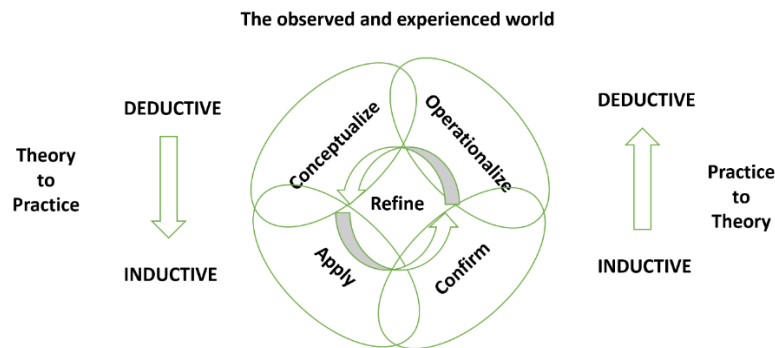


Figure 4-6: Building theoretical foundation based on Swanson and Chermack (2013).

Thorough and meticulous theory development necessitates holistically examining problems and practical areas. Application-focused disciplines suffer significantly when there is an imbalance between theoretical concepts and practical applications. Therefore, a structured approach is essential to maintaining equilibrium between theory and practice in these fields. The General Method of Theory Building in Applied Disciplines proposed by Swanson and Chermack (2013) offers a way to effectively merge theoretical and practical aspects in complex scenarios. The theory formulation's inception can be rooted in innovative concepts or practical experiences. The distinct advantage of this method is its flexibility in supporting various starting points in developing theories. The critical aspect of fostering growth and progress in applied disciplines is acknowledging and integrating the dynamic relationship between creating new ideas and their practical application.

4.5 Terminology unification

Globally, numerous nations are beginning to perceive the curriculum as a fundamental component of extensive educational changes for targeting enhanced learning results.

Modern approaches to curriculum development are increasingly incorporating open dialogues and consultations with various stakeholders. As a result, curriculum topics are gradually becoming a subject of discussion among a wide array of participants, including policymakers, specialists, educators, and the public in general.

The language surrounding the curriculum is no longer exclusive to experts familiar with its intricate aspects, leading to potential misunderstandings and misinterpretations. Often, terms related to the curriculum are used interchangeably, despite representing distinct ideas. The meaning of the same term can vary widely, depending on the context and the perspectives of different stakeholders. A prime example is the variety of meanings ascribed to the term “curriculum,” which, interestingly, does not even have an equivalent in many national languages (IBE-UNESCO, 2013).

ISO 704:2009 encompasses fundamental principles and methodologies for undertaking terminological tasks: choosing appropriate terms, defining concepts, crafting definitions, and more. The process of harmonizing terminology becomes crucial when examining diverse information sources originating from different contexts. This terminological activity focuses on creating a set of terms that enable unambiguous communication in natural language. As this international standard outlines, such terminological efforts aim to clarify and standardize concepts and terms to facilitate communication among people. These terminological endeavors are essential for feeding information and data modeling. Key elements of this work include objects, concepts, designations, and definitions, forming the cornerstone of this unification process (ISO, 2009). Objects are observed, conceptualized, and abstracted into concepts, represented through designations and definitions in specific languages, such as pre-conceptual schemas. The collection of designations within a particular language forms the terminology of a specific subject area.

4.6 System validation and verification

IEEE 1012-2016 represents an IEEE standard focused on verifying and validating systems, software, and hardware. According to the IEEE (2016) guidelines, these verification and validation activities are integral technical aspects of systems, software, and hardware engineering. Verification and validation (V&V) processes are closely intertwined and mutually enhanced. The primary objective of V&V is to assist organizations in embedding

quality into their systems throughout the development lifecycle. These processes evaluate requirements' correctness, completeness, accuracy, consistency, and testability. V&V plays a crucial role in confirming that the outcomes of any development phase align with the specified requirements and that the final product meets its intended purpose and user expectations.

Mangeruca (2017) stated that verification ensures that requirements are met, as depicted in Figure 4-7, while validation is conducted to ascertain the end user's acceptance of the implementation. Thus, verification and validation techniques for systems can be applied to theoretical proposals. This implies that the underlying theoretical principles should be approached as a system.

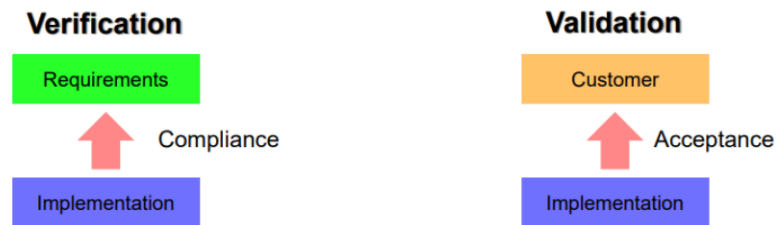


Figure 4-7: Verification and validation processes (Mangeruca, 2017).

An important suggestion for introducing a hazard analysis method within the nuclear scenario has been presented. López (2015) noted that the foundation for verification and validation processes is grounded in IEEE 1012, allowing these tasks to be adapted to model-based scenarios beyond just software and hardware. Similarly, within the same nuclear context, Rudakov and Dickerson (2017) proposed that a model-based approach can serve as a starting point for examining a coherent model from a system perspective, in line with the IEEE 1012 standard.

Another contribution proposes investigating the application of the IEEE 1012-2016 standard for validating and verifying systems concerning non-physical entities (Matthews, 2023). In this case, Matthews (2023) focused on a policy-making scenario for artificial intelligence regulation. In this research, the author explored treating a model as a system. This approach allows them to execute verification and validation processes on the policy model using established formal standards (Matthews, 2023).

4.7 Additional material

Another important source of information that is relevant to this research is described below. Thus, the spirit of this research is enriched by contemplating a general methodological framework for the integration of research steps, also an extensive bibliography on research related to Essence and a compilation of Delphi data for formal definitions of methods.

4.7.1 Action Design Research (ADR)

The authors of Action Design Research (ADR) expose the limitations of traditional Design Research (DR) in the Information Systems discipline, which often emphasizes technology while neglecting the influence of organizational context on Information technology (IT) artifacts (Sein *et al.*, 2011). To address these shortcomings, the authors introduce ADR as a new methodology. ADR posits that IT artifacts are not merely technological products but are shaped by their organizational environments during both development and use. This approach integrates the building, intervention, and evaluation of the IT artifact as simultaneous, intertwined activities throughout the research process. ADS outlines the stages and principles, exemplifying its application through a competence management case at Volvo IT, demonstrating how ADR encapsulates its foundational beliefs and values in a practical setting.

To explore the relationship between action research, design science, and design science research, (Collatto *et al.*, 2018) propose some methods to develop scientific knowledge while addressing real-world problems, sharing common objectives. The study involves a systematic literature review and content analysis to examine the similarities and differences between these approaches. Key findings include notable similarities between the methods, beneficial synergies when combined, and the relevance of artifacts and problem classes in both proposing and evaluating research outcomes. The study suggests the potential for integrating action research with design science research and introduces the concept of ADR as a third method. However, it acknowledges theoretical limitations and calls for further comparative studies to explore these integrations under the design science paradigm.

The way managers are challenged to harness knowledge both inside and outside their organizations to tackle new problems is discussed by (Coghlan *et al.*, 2016). Based on a long-term study with a biopharma company, the authors proposes that combining insider

action research with a well-designed learning mechanism tapestry can boost ongoing organizational learning and improvement. By institutionalizing this learning mechanism, the organization enhanced its agility and stabilized the role and practices of insider action research.

Finally, (Mullarkey & Hevner, 2018) introduce an expanded process model for implementing the ADR approach in immersive industry-based projects. The model builds upon the foundational ADR concepts and delineates four types of ADR cycles: diagnosis, design, implementation, and evolution, focusing on an artefact-based solution. Each cycle involves problem formulation, artefact creation, evaluation, reflection, and learning. The model promotes rapid iterations of these cycles to effectively manage and execute ADR projects as they develop. It offers multiple starting points, allowing adaptation based on the specific circumstances of the problem and project goals. This comprehensive ADR process model aims to facilitate a more flexible yet structured approach to initiating, managing, reflecting on, and presenting ADR projects that are both rigorous and relevant.

4.7.2 SEMAT Essence-based research

Essence-related research is abundant, due to the usage and application in software engineering scenarios. Considering some SEMAT Essence-based research literature into themes, we propose an organization into themes, like this:

- Educational Applications and Teaching

This theme includes papers focused on using the SEMAT Essence in educational settings, training, and curriculum development.

- Framework and Method Integration

Research under this theme discusses integrating the SEMAT Essence framework with various software engineering practices and methods.

- Practical Applications and Case Studies

Papers that provide empirical evidence, case studies, or practical applications of the SEMAT Essence in real-world projects.

- Software Development and Process Improvement

This theme explores how the SEMAT Essence is utilized for process improvement and development strategies in software projects.

According to the above, a condensed information of the SEMAT Essence-based research literature, organized by Authors, Year, and Main Theme is depicted in Table 4-1. This table summarizes the key information about each piece of literature, categorized into thematic areas based on their focus and contribution to the field of software engineering using the SEMAT Essence framework.

Table 4-1: Main themes in a literature review on SEMAT Essence-based research.

Authors	Year	Main Theme
Ciancarini, P. & Missiroli, M.	2020	Educational Applications and Teaching
Castro, L. F. <i>et al.</i>	2020	Educational Applications and Teaching
Kajko-Mattsson, M.	2015	Educational Applications and Teaching
Pieper, J. <i>et al.</i>	2017	Educational Applications and Teaching
Holtappels, S. <i>et al.</i>	2016	Framework and Method Integration
Giray, G. <i>et al.</i>	2016	Framework and Method Integration
Savić, V. & Varga, E.	2018	Framework and Method Integration
Uysal, M. P. & Giray, G.	2017	Framework and Method Integration
Quintanilla-Perez, D. <i>et al.</i>	2019	Practical Applications and Case Studies
Dahhane, W. <i>et al.</i>	2017	Practical Applications and Case Studies
Morales-Trujillo, M. E. <i>et al.</i>	2016	Practical Applications and Case Studies
Elvesæter, B. <i>et al.</i>	2013	Practical Applications and Case Studies
Brandt, S. <i>et al.</i>	2017	Software Development and Process Improvement
Park, J. S. <i>et al.</i>	2018	Software Development and Process Improvement
Jana, D. & Pal, P.	2020	Software Development and Process Improvement

The SEMAT Essence framework has shown significant versatility and impact across various facets of software engineering, as demonstrated by the diverse body of literature reviewed. From enhancing educational methods in software engineering to integrating and refining development practices, SEMAT Essence provides a foundational structure that

supports both theoretical and practical advancements. The literature indicates a strong inclination towards using the SEMAT Essence framework to bridge gaps between educational settings and industry requirements, highlighting its role in curriculum development and pedagogical strategies. Moreover, case studies and practical applications emphasize its effectiveness in streamlining processes and improving project outcomes within professional environments. The ongoing exploration and adaptation of the SEMAT Essence framework suggest its potential to shape future trends in software engineering, encouraging a more structured yet flexible approach to managing software development complexities. This body of work not only reinforces the value of SEMAT Essence in contemporary software engineering practices but also sets a promising direction for future research and application in the field.

4.7.3 Delphi data collection

The Delphi Method is a structured communication technique, originally developed as a systematic, interactive forecasting method which relies on a panel of experts. The key features of the Delphi Method include Expert Panel, Anonymity of the Participants, Iterative Rounds, Aggregation of Responses, Application Areas, Feedback Mechanism, and Conclusions (Skinner et al., 2015). The Delphi Method was developed in the early 1950s by researchers at the RAND Corporation, a nonprofit global policy think tank in the United States. The technique was initially created for the U.S. Air Force to forecast the impact of technology on warfare. The principal developers of this method were Olaf Helmer, Norman Dalkey, and Theodore Gordon. The method was named after the Oracle of Delphi, a nod to its aim of forecasting the future through systematic and structured expert judgment.

Although it is true that the Delphi method has been widely used in different scenarios, as part of its nature, the iterative use of questionnaires is required. In this way, some of the steps of this method can be used for research such as the one proposed in this document.

5. Research development and proposed solution

Our research is anchored in a qualitative paradigm with some complements of the quantitative paradigm, prioritizing the depth and richness of the data collected. This paradigm allows us to explore complex phenomena within their natural settings, granting us the flexibility to understand and interpret the nuances and subtleties inherent in human behavior and experiences. The qualitative approach is particularly well-suited to our research goals, as it enables us to delve into the subjective interpretations and meanings that participants assign to their experiences, thus providing a comprehensive understanding of the research topic (Fugard & Potts, 2015).

The approach we adopted for this study is quasi-experimental. This approach is characterized by deliberately manipulating or introducing a variable into a natural setting to observe the resultant effects, sometimes in a qualitative and quantitative way. This is beneficial due to qualitative and quantitative research can be combined to enhance the validity of the results, much the same as in triangulation, but now using both quantitative and qualitative approaches, for their combined strength, rather than using one method to validate the result of the other (Daly *et al.*, 1992). While it shares similarities with traditional experimental methods, the quasi-experimental approach does not require random assignment to the control and experimental groups. This approach is ideal for our study, as it allows for a more practical examination of the phenomena in settings where complete control over variables is not feasible, thus enabling us to balance experimental rigor and real-world relevance (Asgari & Baptista, 2011).

The cornerstone of our research method is the General Method of Theory Building in Applied Disciplines (Swanson & Chermack, 2013). This method is highly pertinent to our study and provides a structured yet flexible framework for developing theories in applied fields. The method emphasizes integrating theory and practice, making it particularly effective in complex, real-world scenarios. The method allows for starting with new ideas

or in practice, thus accommodating various starting points for theory development. This systematic and dynamic approach allows us to refine our theories based on ongoing observations and findings iteratively. It supports the construction of robust and relevant theoretical frameworks that can be applied to practical situations, thereby bridging the gap between theoretical research and practical applications.

5.1 Identifying common items

A comprehensive review of a century's literature on curriculum design reveals that scholars have meticulously delineated various suggested methods, embedding a set of recommended practices within them. These methods, steeped in theoretical underpinnings and pedagogical expertise, offer a blueprint for systematic curriculum development. Despite the availability and accessibility of these scholarly suggestions, many curriculum designers tend to veer away from these proposed frameworks, instead cultivating their own practices. This divergence, while notable, does not imply a complete disassociation from theoretical guidance. Interestingly, a closer examination reveals the existence of underlying commonalities between the practices outlined in the theoretical literature and those developed through empirical, on-the-ground experience, as depicted in Figure 5-1. This intersection suggests a more nuanced relationship between theory and practice in curriculum design. This indicates that even when curriculum designers deviate from established theories, they often inadvertently align with certain fundamental elements of these theoretical models.

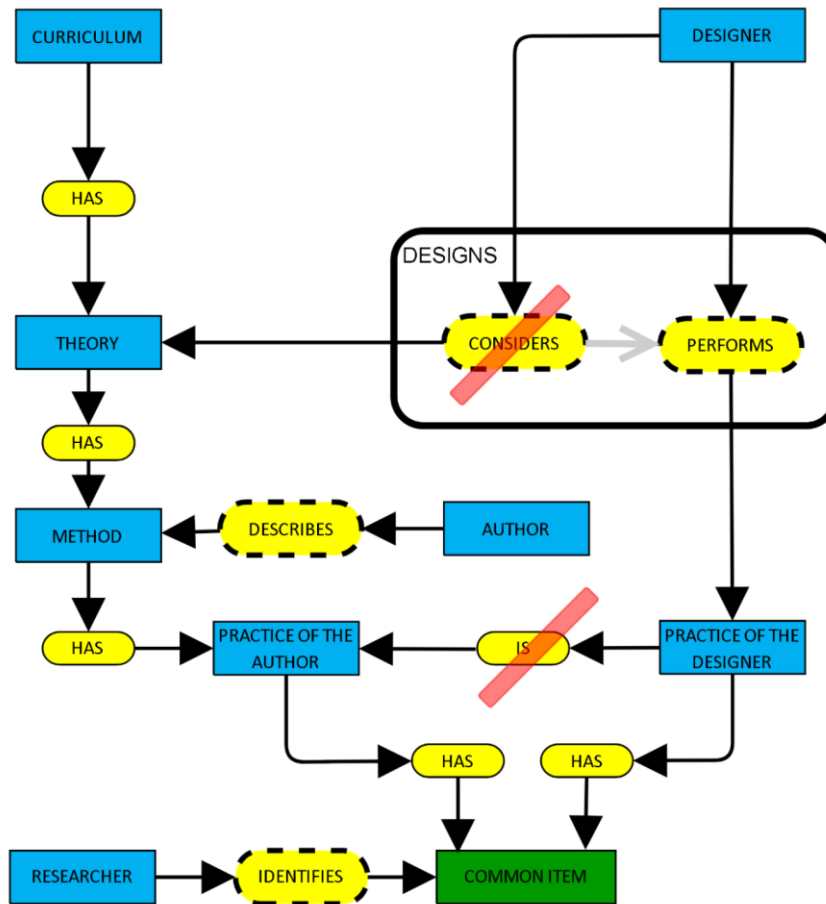


Figure 5-1: Common items between practices of curriculum design.

The intricate nature of curriculum design is tied to the diverse scenarios in which this activity unfolds. Recognizing this variety, Figure 5-2 visually represents these potential environments, each illustrating a unique context in which curriculum design is applicable. This depiction highlights the versatility and broad applicability of curriculum design processes. It underscores that the same foundational principles of curriculum design can be adapted to many situations, leading to a wide spectrum of applications and resultant products. IBE-UNESCO promotes the scenarios depicted in Figure 5-2 for organizing people to design curriculum proposals from a small to a large scale, exemplifying the adaptability and relevance of curriculum design across different educational landscapes. This diversity highlights the design process's complexity and opens avenues for innovative and context-specific curriculum development tailored to each educational scenario's unique needs.

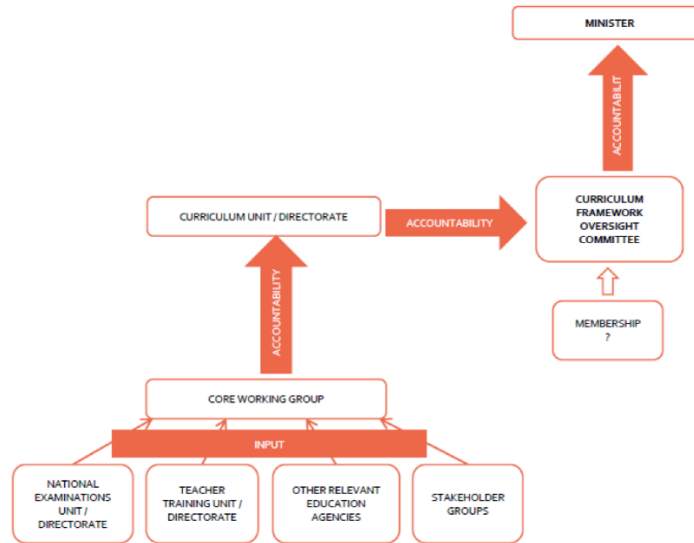


Figure 5-2: Scenarios for curriculum design based on IBE-UNESCO (2017).

Further, van den Akker (2003) presented a nuanced approach to understanding curriculum design, introducing a series of distinct levels of application along with the potential products that emerge from these processes, as detailed in Figure 5-3, which lays out a hierarchy of application levels. Each level is accompanied by examples of curriculum products that could result from curriculum design activities at that stage. Thus, Figure 5-3 summarizes the complexity and diversity of curriculum design expressed in terms of levels and products, highlighting its transformative potential in various educational contexts.

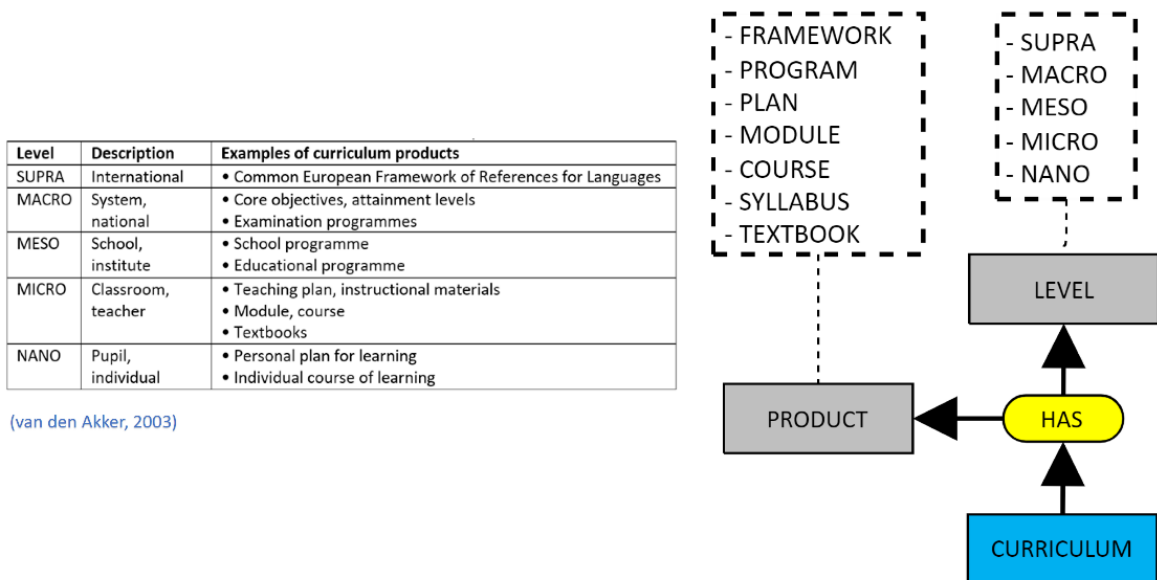


Figure 5-3: Levels and products in curriculum design, based on van den Akker (2003).

Building upon van den Akker's foundational work (2003), he proposes 10 key components that are integral to the curriculum design process. These 10 components are essential in crafting effective curriculum design and are cohesively unified. Figure 5-4 is a comprehensive visual representation that integrates van den Akker's proposals: the various curriculum design levels, products, and the 10 critical components. Figure 5-4 is instrumental for educators and curriculum designers in understanding and implementing van den Akker's methodologies coherently and structurally.

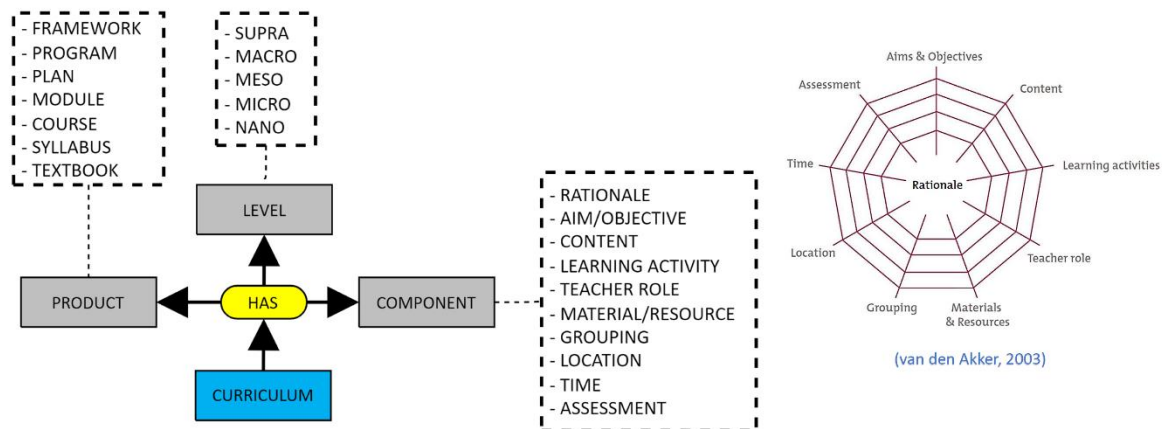


Figure 5-4: Level, products, and components of curriculum design based on van den Akker (2003).

In an ambitious effort to gather insights from leading academic minds in curriculum design in the field of computing and its associated disciplines, the 2019 Academic Ranking of World Universities (ARWU) by Shanghai Jiao Tong University was used as a starting point to meticulously sift through this prestigious list, focusing on the top one thousand universities globally (ARWU, 2019). Our extensive research identified a pool of professors renowned for their expertise in curriculum design, as depicted in Figure 5-5. A 'Call for Action,' (see Annex C) inviting them to contribute their valuable perspectives through a survey, was conducted as they agree with the informed consent (see Annex E). A total of 226 professors from various corners of the globe agreed to participate. Figure 5-6 details the demographic data of these participants, providing a snapshot of the elite academic minds that shaped our survey's findings. However, a discrepancy emerges when tracing the use of the components proposed by van den Akker, both through the academic literature and the professors' responses to the survey (see Annex D). The percentages derived from this analysis paint a telling picture. Empirically, in the experiences documented

in academic papers and survey responses, van den Akker’s proposed components are utilized remarkably discreetly.

Rank	University	Country	Faculty/School/Department/Center/Institut	Account	Emails
1	Harvard University	us	Harvard John A. Paulson School of Engineering	21	namini
2	Stanford University	us	Computer Science Department	53	lloyd@
3	University of Cambridge	uk	Department of Engineering (Information Engine	33	sb293@
4	Massachusetts Institute of Technology (MIT)	us	Department of Electrical Engineering and Comp	31	fadel@
5	University of California, Berkeley	us	Department of Electrical Engineering and Comp	136	pabber
6	Princeton University	us	Department of Computer Science	62	rpa@c
7	University of Oxford	uk	Department of Computer Science	53	alessa
8	Columbia University	us	Computer Science Department	62	allen@
9	California Institute of Technology	us	Department of Computing + Mathematical Scier	38	yaser@
10	University of Chicago	us	Department of Computer Science	67	htzhen
11	University of California, Los Angeles	us	Computer Science Department	61	aviz@c
12	Yale University	us	Department of Computer Science	26	dana.a
13	Cornell University	us	Computer Science Department	96	zhiruz
14	University of Washington	us	Paul G. Allen School of Computer Science & Eng	84	althoff
15	University College London	uk	UCL Computer Science	133	D.Adar
997	Williams College	us	Computer Science Department	17	jeanni
998	Worcester Polytechnic Institute	us	Department of Computer Science	42	cew@v
999	Wroclaw University of Technology	pl	Department of Computer Science and Systems E	1	emails
1000	Yokohama National University	jp	Computer Science and Engineering Program	9	shirak
1001	Zagazig University	eg	Department of Computer Science	1	emails
1002				29,730	

Figure 5-5: Excerpt of the potential list of participants in the “Call of Action.”

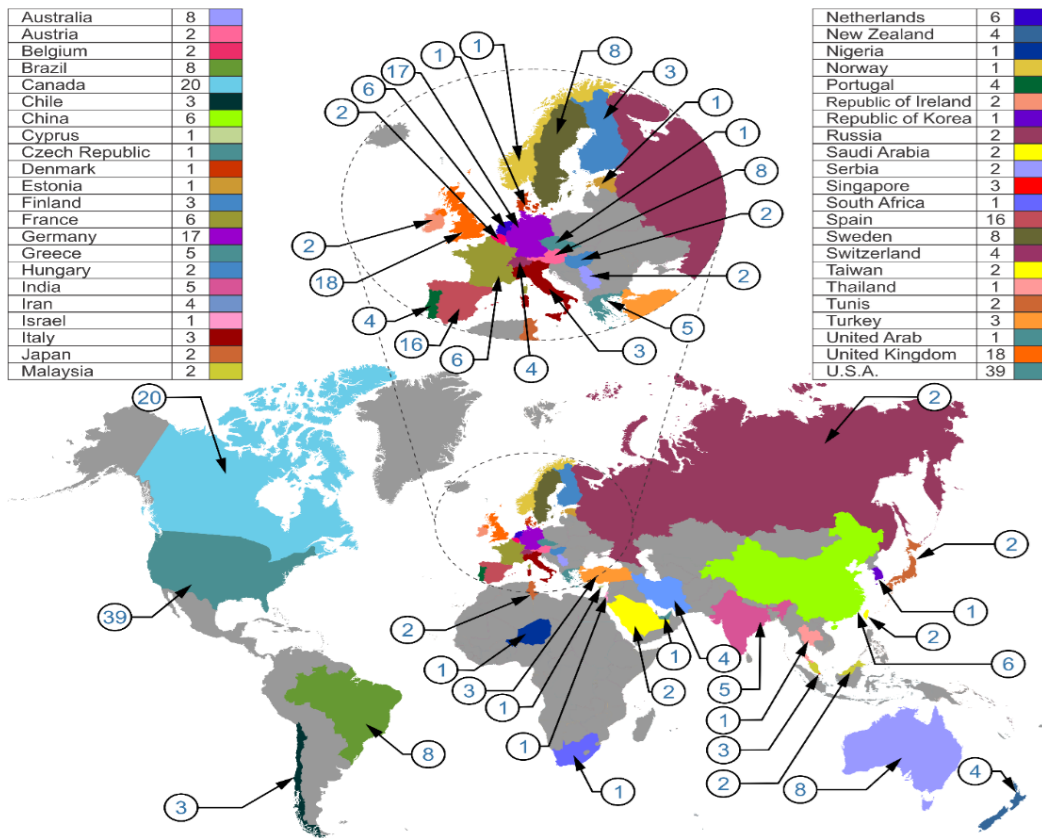


Figure 5-6: 226 professors worldwide who participated in the survey.

This suggests a subtle yet significant divergence between theoretical curriculum design frameworks and their practical applications. While van den Akker’s components are recognized and appreciated in theory, their presence in real-world educational settings is far less pronounced. This gap between theory and practice highlights a potential disconnect or underutilization of these components in the day-to-day realities of curriculum design. The findings depicted in Figure 5-7 prompt a reevaluation of how theoretical models are integrated into practical educational scenarios.

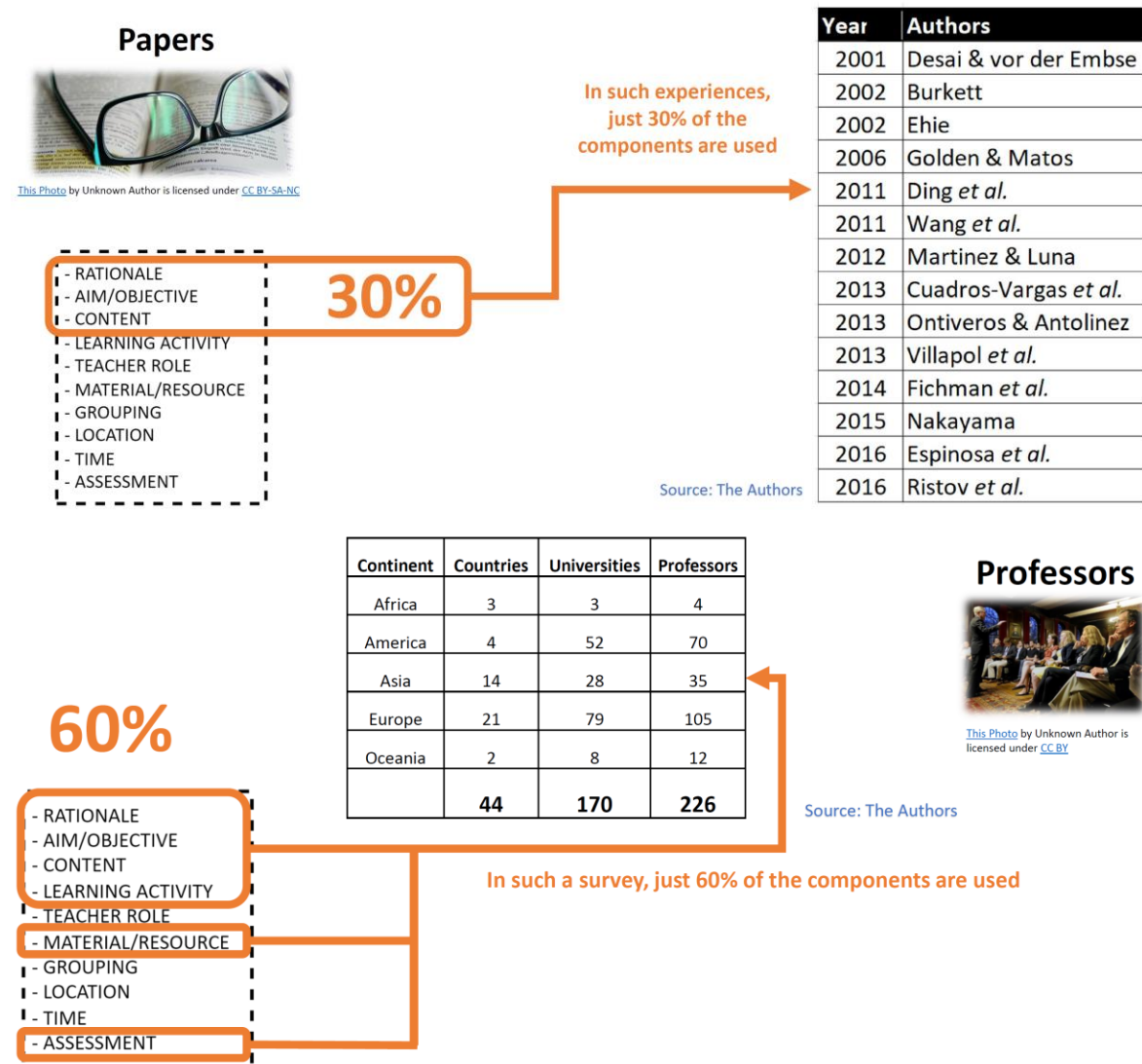


Figure 5-7: Identifying van den Akker’s components in papers and survey responses.

5.2 Creating a linguistic corpus

An extensive compilation of textual information encompassing three primary sources was undertaken to construct a comprehensive linguistic corpus. First, the corpus thoroughly reviewed a century's literature on curriculum design theory (22 methods from the literature review), providing a historical and theoretical perspective. Second, it incorporated insights from 14 seminal papers on documented experiences in curriculum design (also from the literature review), offering practical viewpoints and applications. Lastly, the corpus was enriched with responses from a survey conducted with 226 professors worldwide (inspired by parts of the Delphi method in the selection of experts and application of at least one round of questionnaires), adding a diverse experiential dimension to the dataset. This multifaceted compilation of text is visually synthesized in Figure 5-8, which serves as a graphical representation of the corpus composition.

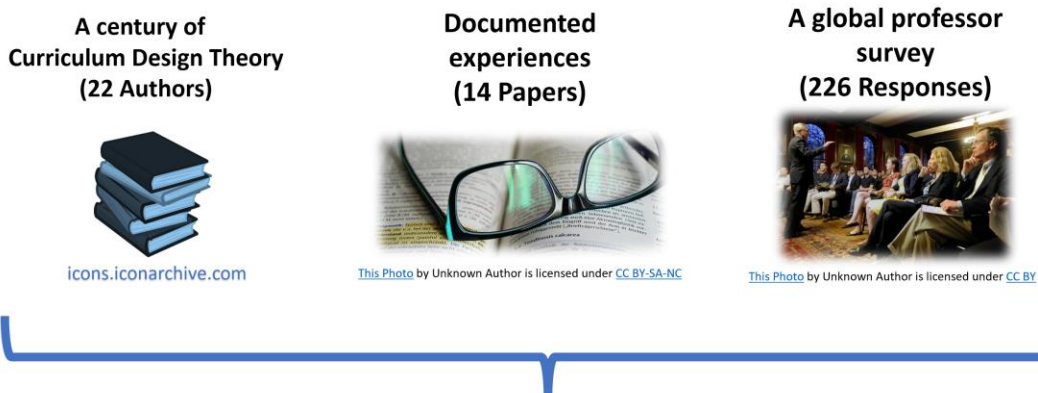


Figure 5-8: Sources of the linguistic corpus.

NVIVO version 12 software, a renowned tool for qualitative data analysis, was employed to structure the linguistic corpus effectively. This advanced software facilitated the organization and analysis of the substantial volumes of text that constitute the corpus. The data compiled included an extensive review of a century's worth of curriculum design theory literature, providing a deep dive into historical and theoretical perspectives. Additionally, the corpus encompassed insights from 14 academic papers on documented experiences in curriculum design, offering a practical lens for the study. Moreover, the corpus was enriched with responses from a survey featuring open questions completed by 226 professors worldwide. These responses shed light on professors' diverse methods and

practices in curriculum design and include their reflections and comments on the process. NVIVO version 12 enabled a systematic and thorough analysis of this rich, varied textual data, allowing for a nuanced understanding of curriculum design practices and theories across different contexts. Figure 5-9 depicts the structure of the linguistic corpus within NVIVO, represented as a word cloud.

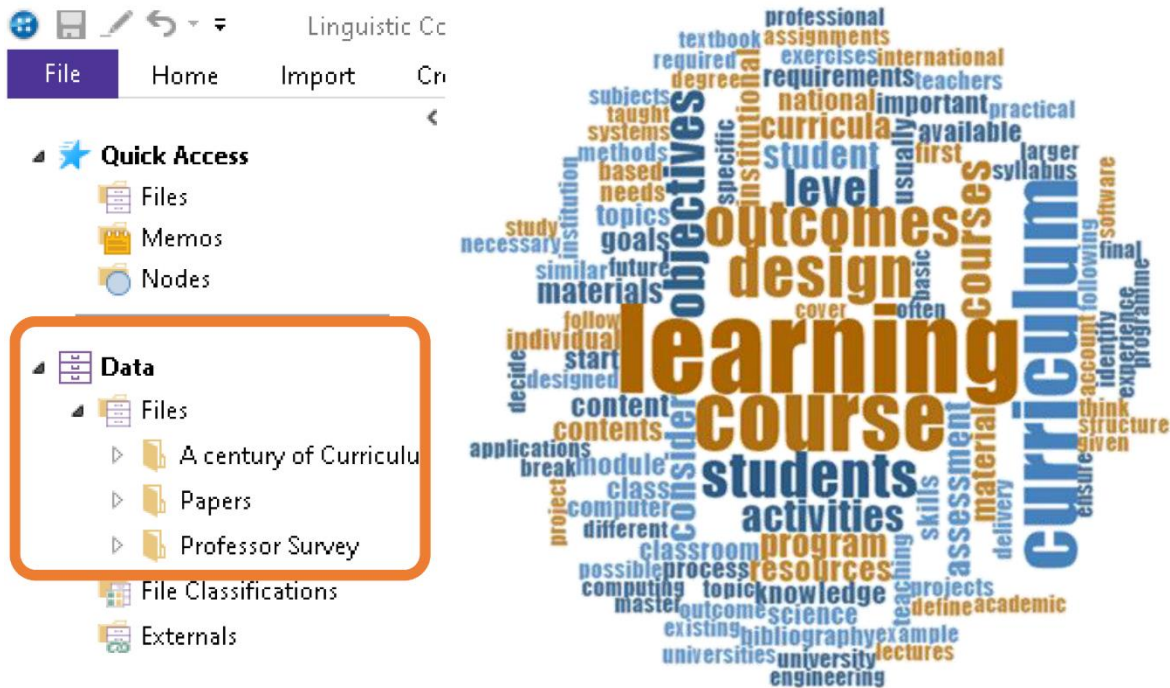


Figure 5-9: First representation of the linguistic corpus using a word cloud.

The linguistic corpus is characterized by a network of semantic relationships, the strength of which is contingent upon the meanings embedded within the corpus. These relationships are not merely linear or superficial; they represent a complex web of interconnected ideas and themes. Figure 5-10 offers an insightful three-dimensional representation of this phenomenon, illustrating how the primary concepts within the linguistic corpus exert a ‘gravitational attraction’ relative to their frequency and significance of use. This visualization metaphorically portrays the concepts as celestial bodies, with their ‘gravitational pull’ indicating the extent of their influence and centrality within the corpus. Such a depiction not only aids in understanding the relative importance of each concept but also visually encapsulates the dynamic interplay and cohesiveness among them. This representation provides a unique perspective on this corpus, highlighting the intricate and multi-layered nature of semantic relationships in curriculum design theory.

bolstering the effectiveness of curriculum design and other language-focused investigations. Figure 5-11 depicts the results of the cluster analysis.

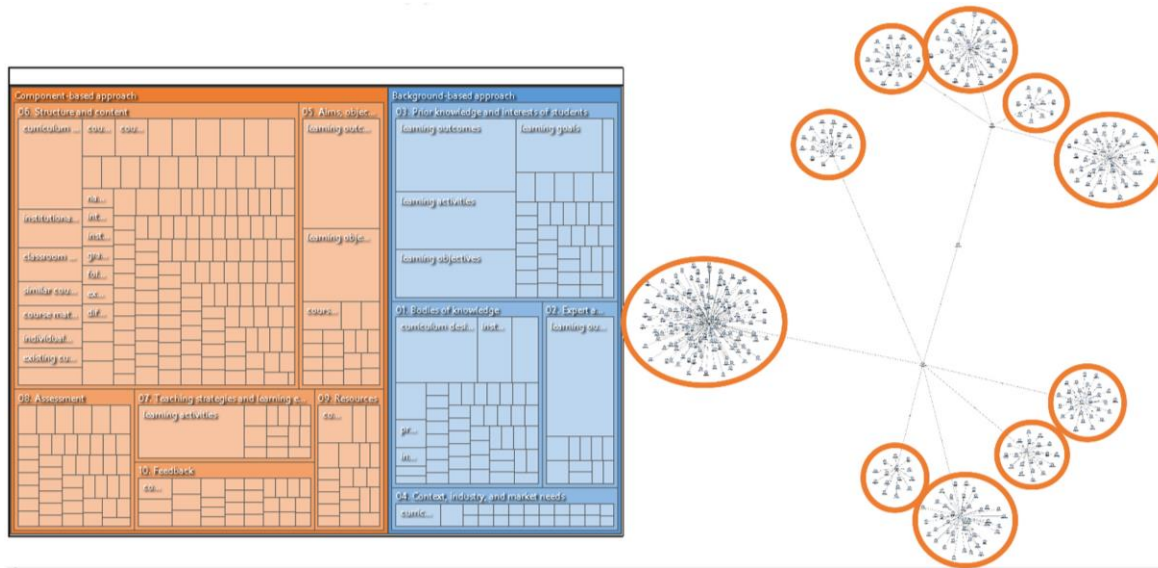


Figure 5-11: Cluster analysis to elicit codes from the linguistic corpus.

Collocation analysis is a fundamental aspect of corpus linguistics that offers critical insights into the combinations of words in natural language. It reveals key syntactic and semantic patterns by examining the usual pairing of words, which is essential for understanding a language's nuanced structure and meaning. The analysis goes beyond traditional linguistic approaches to uncover language peculiarities. McEnery and Hardie (2012) argued that collocations extend beyond frequent word pairings and play a vital role in meaning-making within discourse. Sinclair's groundbreaking work on collocations demonstrated their importance in forming the texture and unity of language (1999). For language education, Hill (2000) pointed out that collocation analysis is vital for enhancing learners' language proficiency and fluency, enabling them to use language naturally and suitably in context. Furthermore, collocation analysis is key in computational linguistics for tasks such as machine translation and NLP, aiding in capturing the nuances and complexities of language use (Manning & Schütze, 1999). This analysis is particularly beneficial in curriculum design for language education for integrating real language patterns into teaching materials.

We recognized key terms, conceptual connections, and thematic links by identifying collocations detailed in Sinclair's proposal (2004). This approach blends syntax analysis with collocation examination and uses advanced computational methods, thus allowing us to uncover the subtle linguistic aspects of curriculum design discourse. This method

revealed prevalent practices and emerging trends, a notion supported by Jurafsky and Martin (2009). This combined methodology enriched our analysis, offering a detailed view of the linguistic construction and interconnections between curriculum design theories and practices. An excerpt of the representations of collocation is depicted in Figure 5-12.

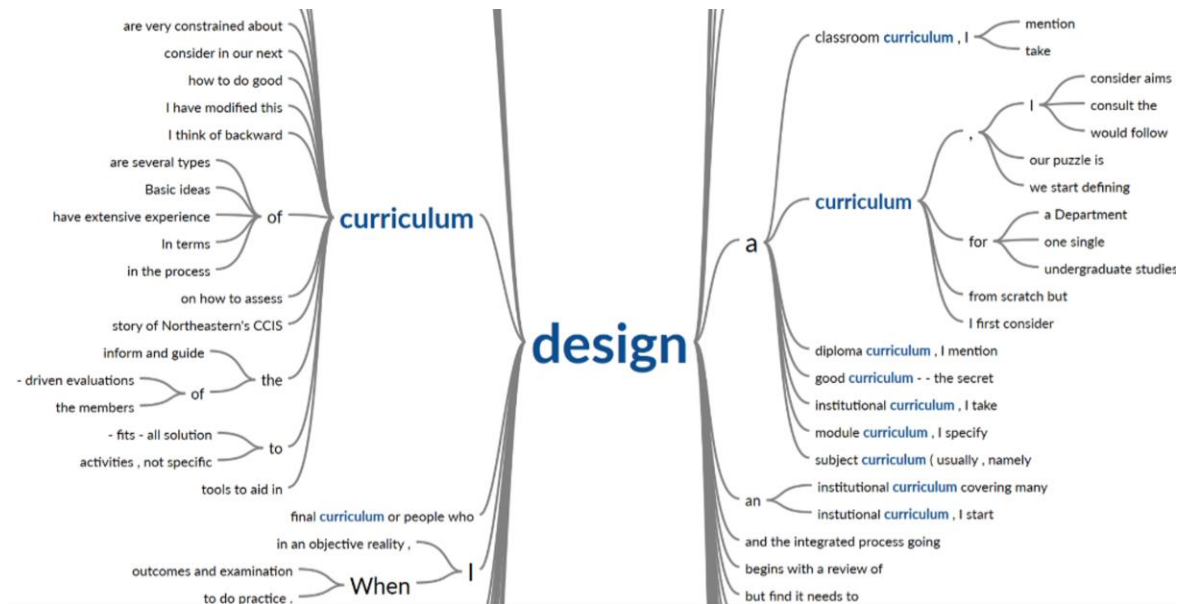


Figure 5-12: Excerpt of a collocation analysis from the linguistic corpus.

5.3 Eliciting common practices

Considering the insights from the cluster and collocation analyses, a structured set of items was constructed to organize the information within the linguistic corpus. This structured set serves as a foundational map, elucidating the intricate connections and thematic alignments present in the corpus. The common items, which emerged as focal points in this structure, are comprehensively visualized in Figure 5-13. This visualization highlights the predominant themes and illustrates each common item’s relationships and relative significance within the corpus. Thus, the figure provides a structured representation of elicited codes and a coherent representation of the corpus’s informational architecture as a graph. This structural arrangement facilitates more intuitive and insightful corpus exploration.

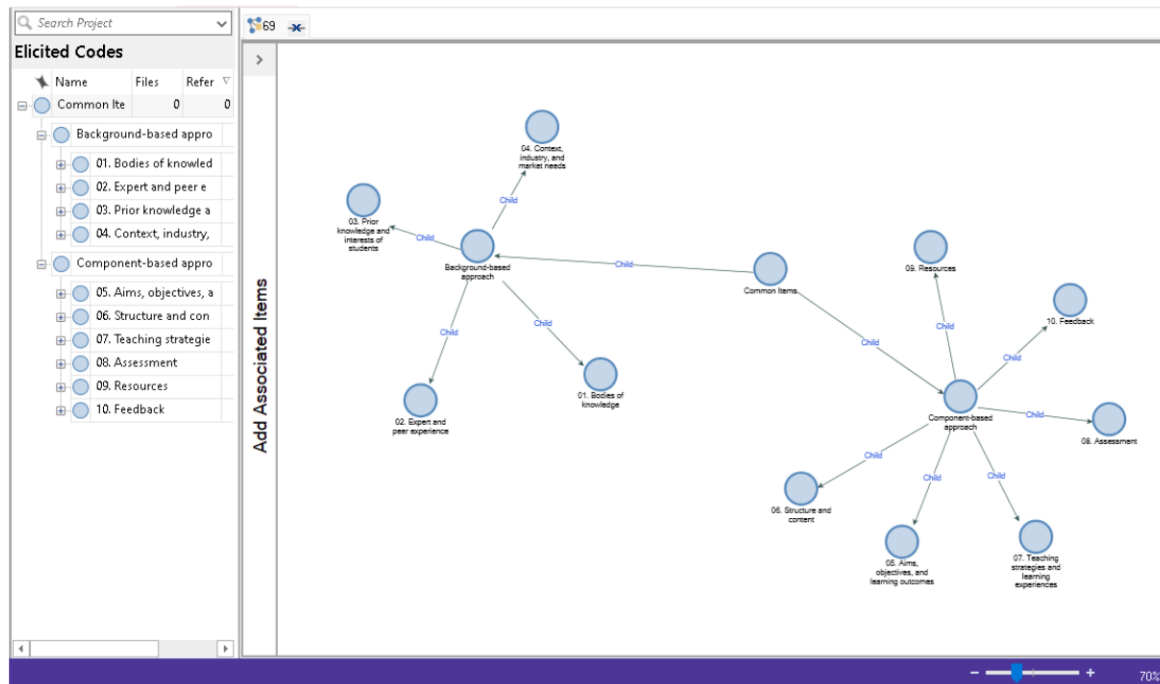


Figure 5-13: Structure of items based on elicited codes from the corpus.

Consequently, we discovered 153 practices spanning 22 distinct methods of curriculum design. Furthermore, our analysis revealed 10 common items consistently incorporated into curriculum designs, which are widely recognized as fundamental in curriculum design theory. These items include:

- Bodies of knowledge
- Expert and peer experience
- Prior knowledge and interests of students
- Context, industry, and market needs
- Aims, objectives, and learning outcomes
- Structure and content
- Teaching strategies and learning experiences
- Assessment
- Resources
- Feedback

By adapting van der Akker's original components to align with the common items identified in our linguistic corpus, our proposed initiative ensures their implicit integration into every aspect of curriculum design. This includes theoretical frameworks, documented practical

experiences, and the insights gathered from surveyed professors. This comprehensive inclusion is exemplified in Figure 5-14, which illustrates the adapted common components incorporated across various dimensions of curriculum design, demonstrating their ubiquitous presence and significance in curriculum design. These common items are categorized into approaches based on their inherent characteristics. Accordingly, the four initial common items are grouped under the background-based approach, while the remaining items belong to the component-based approach.

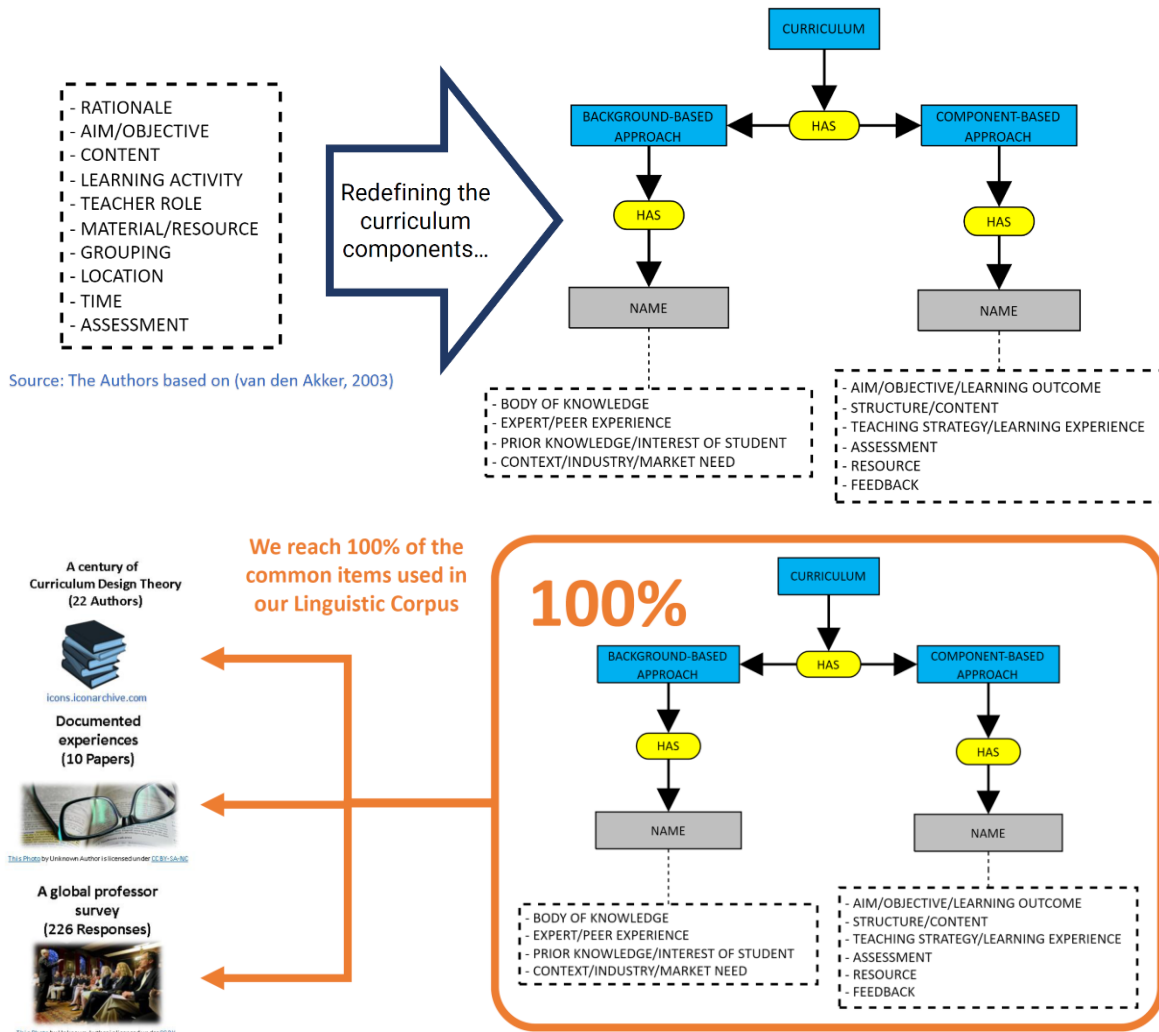


Figure 5-14: Usage of the common items in the linguistic corpus.

In this study, we formulated a definition of curriculum design grounded in insights derived from our linguistic corpus analysis. This conceptualization of curriculum design, including the key elements it should encompass, is outlined in Figure 5-15.

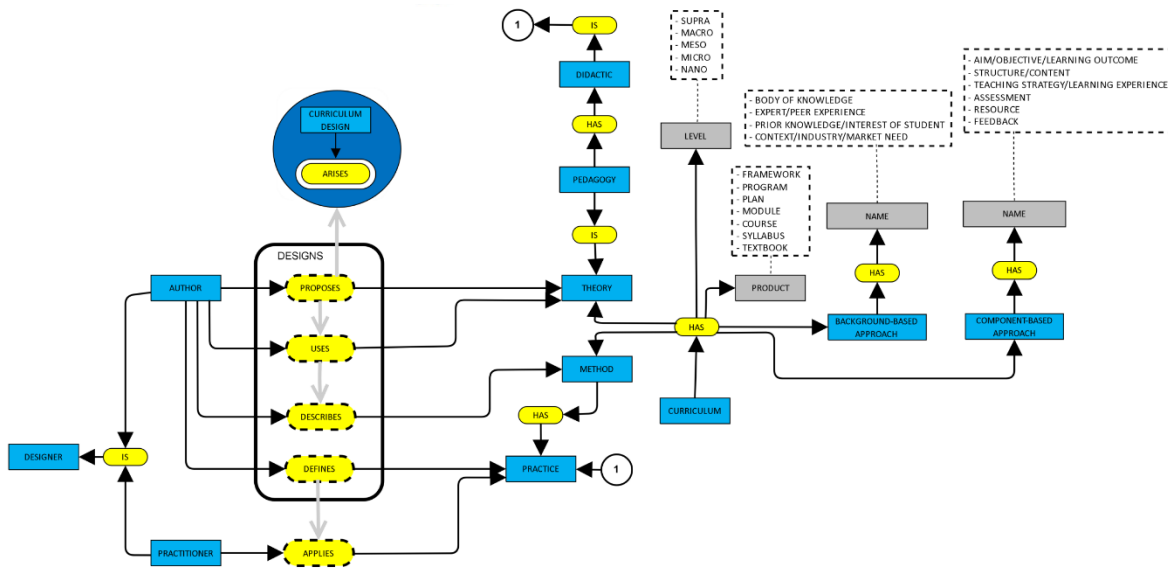


Figure 5-15: Definition of curriculum design according to the findings on the linguistic corpus.

This pre-conceptual schema in Figure 5-15 comprehensively depicts the curriculum design process, encapsulating the multidimensional roles of authors, designers, and practitioners within this proposal. At the heart of the schematic is ‘curriculum design,’ a pivotal concept from which myriad pathways emerge, signifying the progression from theoretical underpinnings to tangible educational products. The left side of the pre-conceptual schema delineates the transition from the ideation phase, during which the authors propose designs, to the practical phase, in which practitioners apply these designs. Interconnected to this is the dual approach to curriculum development: the ‘background-based approach’ and the ‘component-based approach,’ each comprising elements crucial for a holistic design process. Including pedagogical elements such as ‘didactic,’ ‘pedagogy,’ ‘theory,’ ‘method,’ and ‘practice,’ each sequentially numbered, suggests a layered approach to curriculum design. Furthermore, the pre-conceptual schema classifies varying ‘levels’ of curriculum engagement, from ‘supra’ to ‘nano,’ and outlines potential ‘products,’ such as ‘framework,’ ‘program,’ and ‘syllabus.’ This visual representation, as exemplified in Figure 4-15, serves not only as an educational tool but also as a strategic model, guiding the synthesis of curriculum theory into praxis across diverse educational landscapes.

Consequently, this research uncovered 153 distinct practices spread over 22 methods of curriculum design. We also observed that the 10 common items identified previously are consistently present and acknowledged as foundational within curriculum design theory.

Figure 5-16 depicts the distribution of the common items along the practices from the linguistic corpus.

		Common items in curriculum design theory									
		Background-based approach					Component-based approach				
Authors of the method	Method structures	1	2	3	4	5	6	7	8	9	10
#1, Kilpatrick (1918)	1. Purposing			X							
	2. Planning			X			X				
	3. Executing			X	X			X			
	4. Interpreting and Judging										X
#2, Bobbitt (1924)	1. Identifying a domain	X			X	X					
	1.1. Finding the experts		X		X						
	1.2. Analyzing the expert behavior		X		X						
	1.3. Characterizing the student profile and their role			X							
	2. Identifying the activities for such a domain		X		X						
	3. Proposing educational objectives for each activity						X				
#21, OIE-UNESCO (2017)	3.1. Objective-based steps					X					
	3.2. Preparing the material									X	
...											
#22, Ornstein & Hunkins (2018)	1. Evidence-gathering				X						
	2. Preparation					X	X				
	3. Development							X			
	4. Implementation							X		X	
	5. Monitoring and evaluation								X		X
#22, Ornstein & Hunkins (2018)	1. Theoretical foundation	X									X
	2. Design					X	X				
	3. Development							X			
	4. Implementation									X	
	5. Evaluation								X		X

- 1 - BODY OF KNOWLEDGE
- 2 - EXPERT/PEER EXPERIENCE
- 3 - PRIOR KNOWLEDGE/INTEREST OF STUDENT
- 4 - CONTEXT/INDUSTRY/MARKET NEED
- 5 - AIM/OBJECTIVE/LEARNING OUTCOME
- 6 - STRUCTURE/CONTENT
- 7 - TEACHING STRATEGY/LEARNING EXPERIENCE
- 8 - ASSESSMENT
- 9 - RESOURCE
- 10 - FEEDBACK

Figure 5-16: Excerpts of common items distributed in curriculum design practices.

Lastly, the general graph of these 153 practices and their relationships is depicted in Figure 5-17.

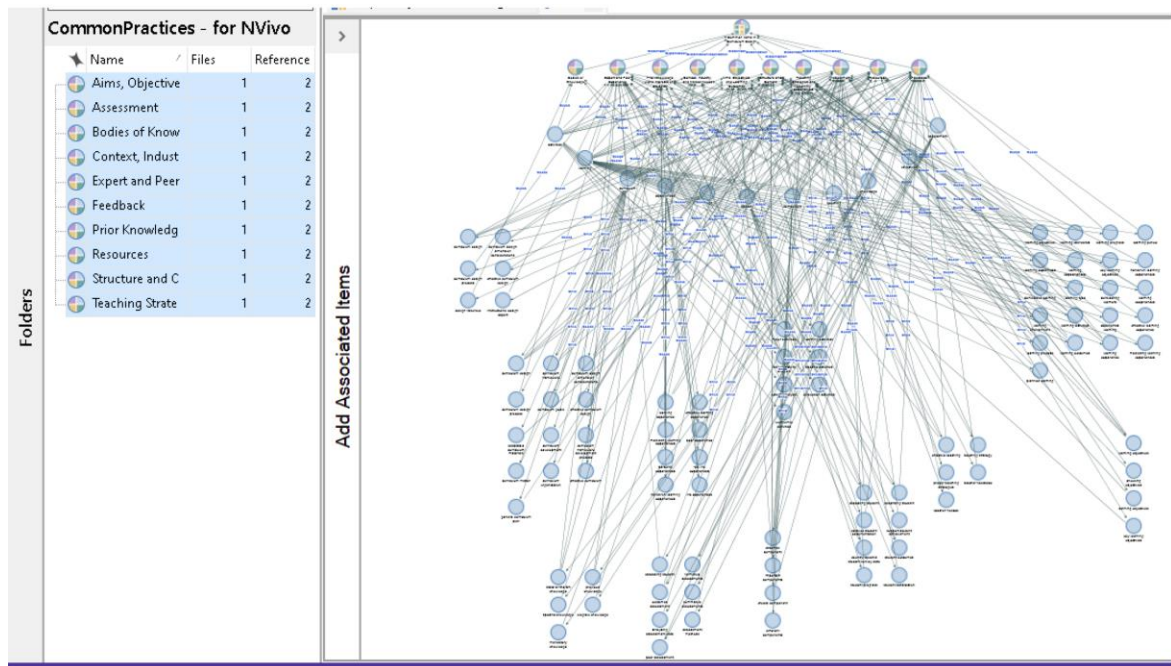


Figure 5-17: Network of 153 practices and their relationships from the linguistic corpus.

After pinpointing the 153 practices within the linguistic corpus, we advanced to retrieving sentences about the structural definition of curriculum design methods. For each retrieved sentence, we conducted a syntactic analysis characteristic of computational linguistics settings. This aimed to identify the constituent words that form the descriptions of the sentences linked to the identified practices. This is evidenced in Figure 5-18.

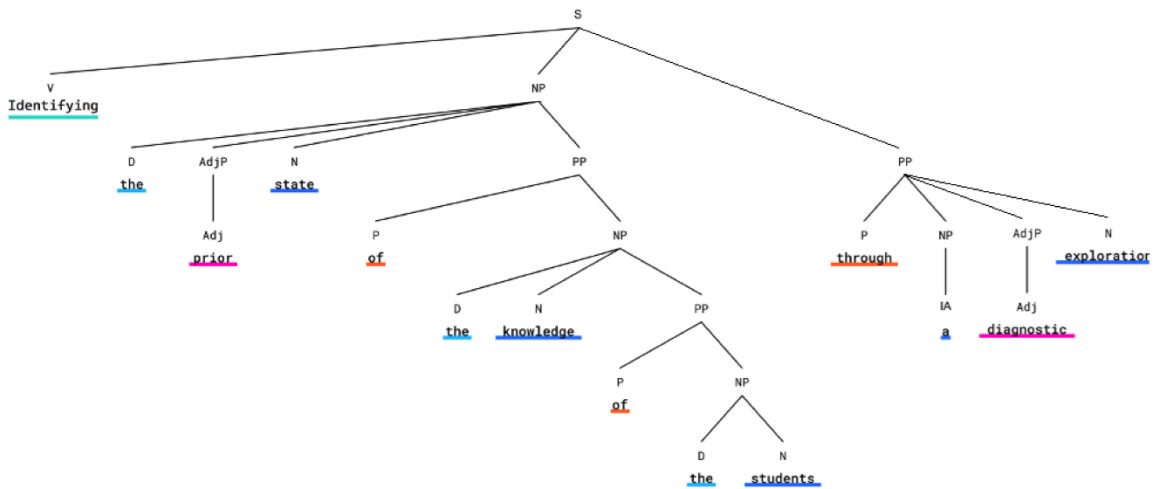
A	B	C	D
Common Item	Practice codes	Theoretical foundation	Practice-related Statements
Prior Knowledge and Interests of Students	001	Prior knowledge refers to the knowledge and skills that a student has already acquired before starting a new learning experiences. This could be knowledge gained from previous courses, personal experiences, or informal learning.	Allowing students to choose what they want to pursue.
	002		Centering the classroom activities around projects that arise from what students want to do.
	003		Doing project-based learning.
	008	Prior knowledge can either facilitate or hinder new learning, depending on how it aligns with the new material being taught. If prior knowledge aligns well with the new material, it can serve as a foundation upon which new concepts can be built. On the other hand, if prior knowledge is incomplete, incorrect, or misaligned with the new material, it can create cognitive barriers to learning. Interests, on the other hand, refer to the things that students find engaging, enjoyable, and motivating. Students are more likely to learn and retain information when they are interested in the topic being taught. Interest can be sparked by a variety of factors, including personal	Giving the students the opportunity to define their profile.
	018		Considering the abilities and interests of students.
	025		Finding relationships between students, contents, and society based on life experiences.
	033		Performing the real-life activity analysis according to the needs of society.
	049		Finding out the needs and interests of students. Focusing on skills, attitudes, and previous knowledge of students.
	071		Designing the material to accommodate the student learning.
	091		Identifying the prior state of students' knowledge through a diagnostic exploration.
092		Proposing and organizing the content with the related activities.	
Context, Industry, and Market Needs	100		Doing project-based learning.
	003	Considering the context, industry, and market needs is important for creating effective educational programs that meet the needs of learners and prepare them for success in their chosen fields. The context of an educational scenario refers to the specific circumstances and environment in which the learning is taking place. This could include factors such as the age and background of the learners, the subject matter being taught, the level of technology available, and the overall goals of the educational program.	Dividing life into major activities. Identify the domains of activity or responsibility.
	005		Finding out what successful or skilled individuals do in life. Locating the vocational abilities.
	006		Analyzing each major activity into specific activities.
	009		Performing the real-life activity analysis according to the needs of society.
	033		Finding out the needs and interests of students. Focusing on skills, attitudes, and previous knowledge of students.
	049		Understanding the culture and society through interaction with people.

Figure 5-18: Excerpts of the practice-related sentences.

Syntax analysis, also known as parsing, is a fundamental aspect of computational linguistics that focuses on studying the rules that govern the structure of sentences. According to Jurafsky and Martin (2009), syntax analysis involves decomposing sentences into constituent elements, enabling an understanding of grammatical structures and the relationships between words. This analytical approach is essential for NLP applications, such as machine translation and speech recognition, in which the syntactic structure provides a framework for meaning interpretation (Chomsky, 2014). Manning and Schütze (1999) highlighted the significance of parsing in developing language models that can simulate human language understanding. Thus, the advancement of syntax analysis algorithms continues to be a core pursuit in the field, with researchers such as Collins (2003) developing models that can accurately predict syntactic dependencies, contributing to the evolution of more sophisticated language technologies. To articulate an exploration of the real nature of the words used in practice-related sentences from the corpus, a syntax analysis was performed on each of them. Figure 5-19 depicts the syntax analysis as a sample of the processing of practice-related sentences.

Statement #091

“Identifying the prior state of the knowledge of the students through a diagnostic exploration”



Statement #092

“Proposing and organizing the content with the related activities”

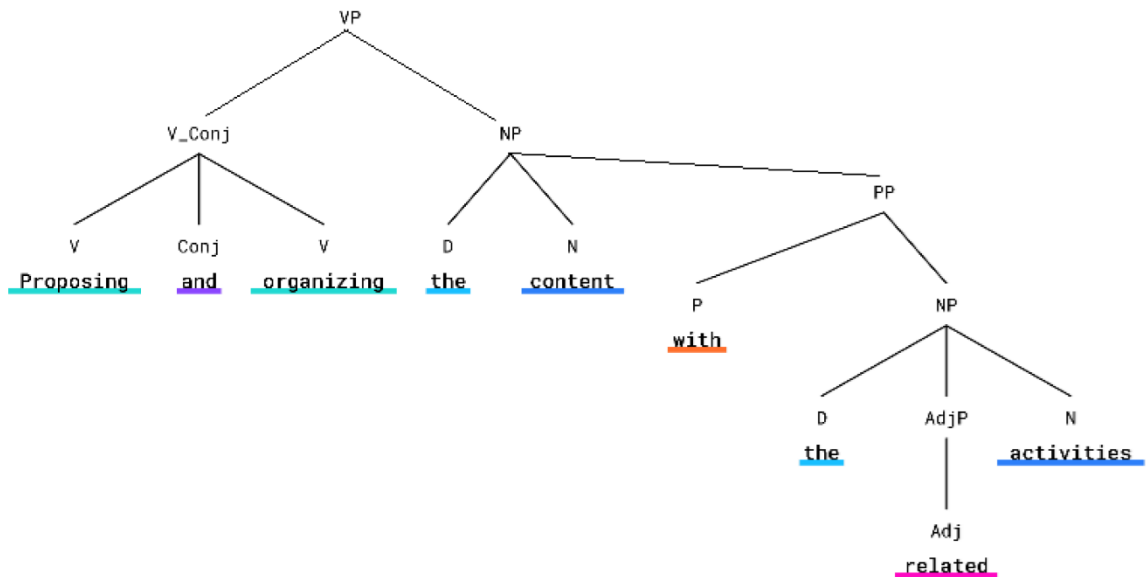
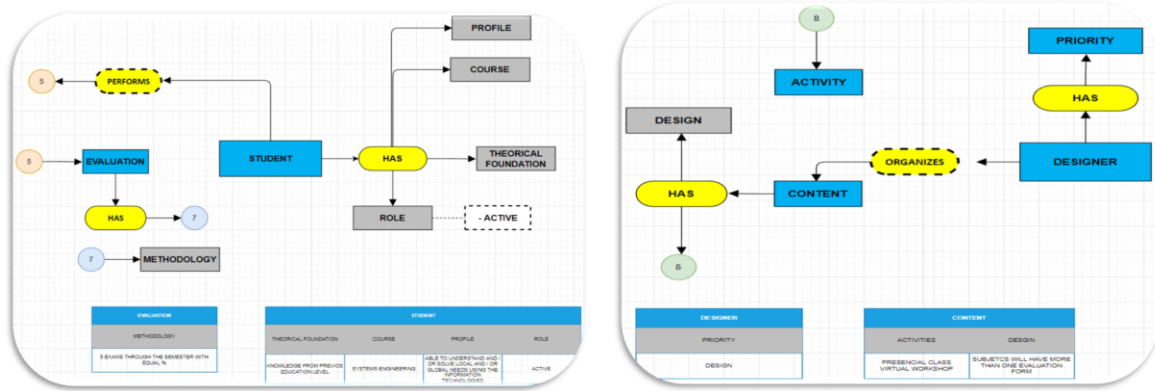


Figure 5-19: Samples of syntax analysis applied to a practice-related statement.

The involvement of students from a requirements engineering course offered during the second semester of 2022 at the Universidad Nacional de Colombia in Medellín resulted in a comprehensive depiction of practices within pre-conceptual schemas. This vital activity led to precisely discerning verbs, nouns, and adjectives and their connections with other representations using pre-conceptual schemas about all the sentences. Consequently, this

process facilitated the identification of a collection of words that carry significant semantic weight, categorized by their function in language. Figure 5-20 depicts some samples from the 153 practices identified and a summary of the verbs, nouns, and adjectives.



Common Item	VERBS	NOUNS	ADJECTIVES
Bodies of Knowledge	7	22	8
Expert and Peer Experience	11	23	12
Prior Knowledge and Interests of Students	22	32	7
Context, Industry, and Market Needs	14	31	13
Aims, Objectives, and Learning Outcomes	26	54	18
Structure and Content	26	54	21
Teaching Strategies and Learning Experiences	30	69	19
Assessment	27	40	3
Resources	8	16	5
Feedback	23	45	9
	194	386	115

Figure 5-20: Samples of representations of a common practice in pre-conceptual schemas and a summary of the verbs, nouns, and adjectives.

The interim outcome presented in the summary stems from tallying the words. After this step, we examined duplicate entries and semantic equivalents among the words and ascertained a count of 84 verbs, 196 nouns, and 77 adjectives. We identified 10 common

practices that synthesize and converge what the theory in curriculum design says about curriculum design. A sample of this activity is shown in Figure 5-21.

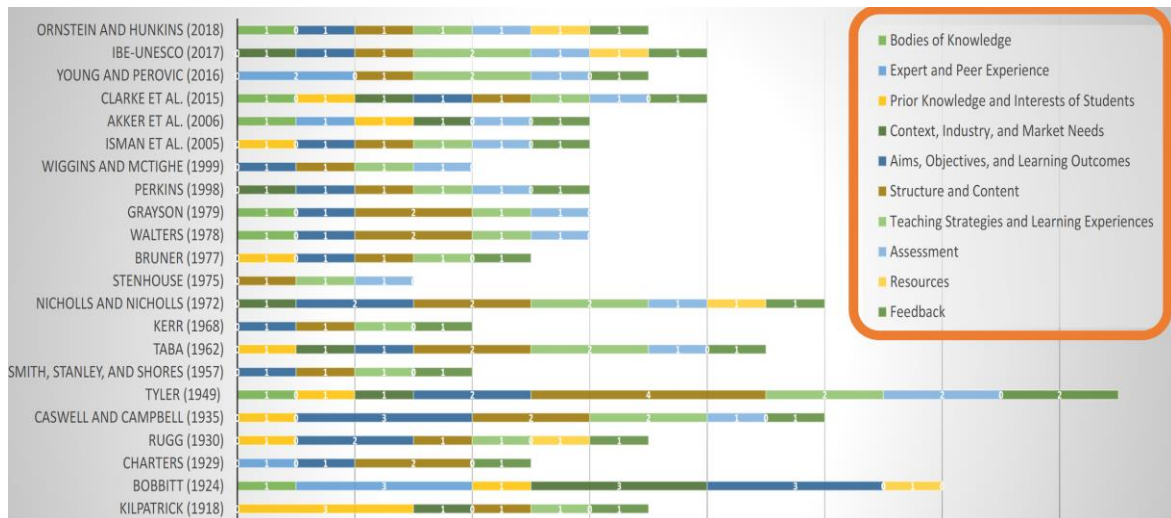


Figure 5-21: Distribution of the 10 common practices.

Each of these common practices communicates with the 10 previously identified items, giving each at least one complete practice that defines the very nature of such items, their usage, and their value in a curriculum design endeavor.

5.4 Unifying terminology

Terminology unification is critical in ensuring consistent and clear communication within and across various fields, and it provides a structured framework for achieving this. The “Terminology work – Principles and methods” standard offers guidelines for establishing and developing terminologies (International Organization for Standardization, 2009). It emphasizes the importance of creating terms that are not only precise and unambiguous but also adaptable and capable of integration into a larger, standardized linguistic system. By adhering to these principles, terminology unification enables different stakeholders, from academics to professionals, to collaborate effectively, reducing misunderstandings and improving efficiency. This process is especially important in globalized contexts, where diverse language and cultural backgrounds can often lead to discrepancies in understanding. Unifying terminology according to ISO 704-2009 helps bridge these gaps, facilitating clearer international cooperation and advancing knowledge transfer across

borders. Figure 5-22 depicts the foundational elements of a theory and the important role of its terminology in relation to associated constructs.

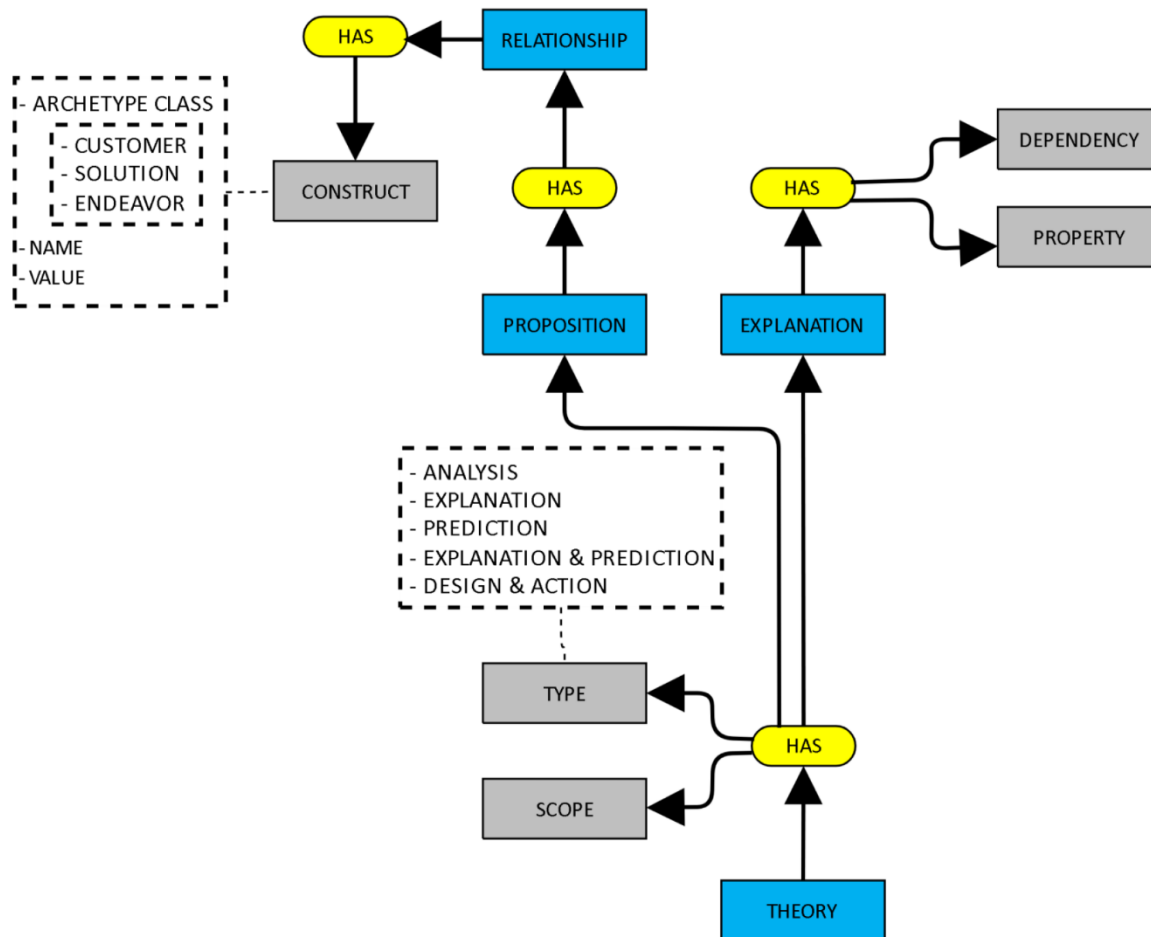


Figure 5-22: An approach to a general theory for software engineering based on Zapata (2014).

Establishing a well-defined and well-formed practice is vital to the terminology unification process. In this context, Barón (2019) introduced a conceptual model designed to harmonize the theoretical framework of practice, including guidelines for its naming and development. The author's framework provides a clear and unified definition of 'practice' as a theoretical concept in software engineering. This model facilitates a cohesive definition, as it can be accurately applied to practices from various methodologies. In other words, the definition allows for illustrating the practice using examples from diverse approaches. Additionally, the model ensures an unambiguous definition by strictly applying it to software practices, excluding other constructs. This specificity enables the model to identify practices

distinctly and unambiguously within the software engineering domain. This definition model is depicted in Figure 5-23.

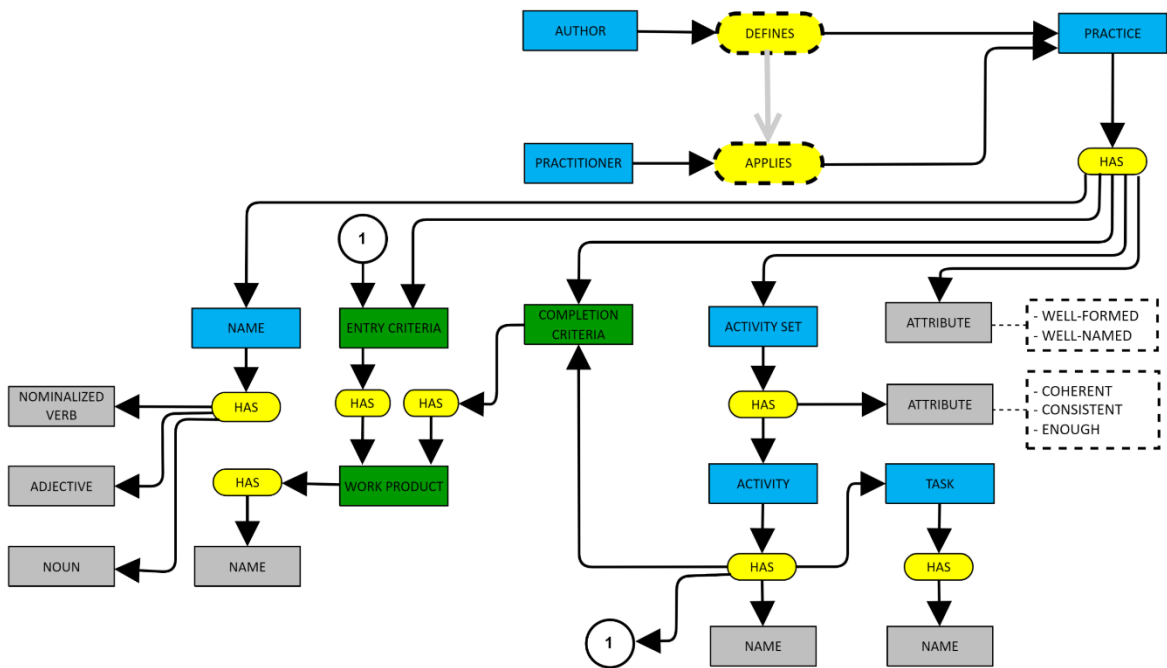
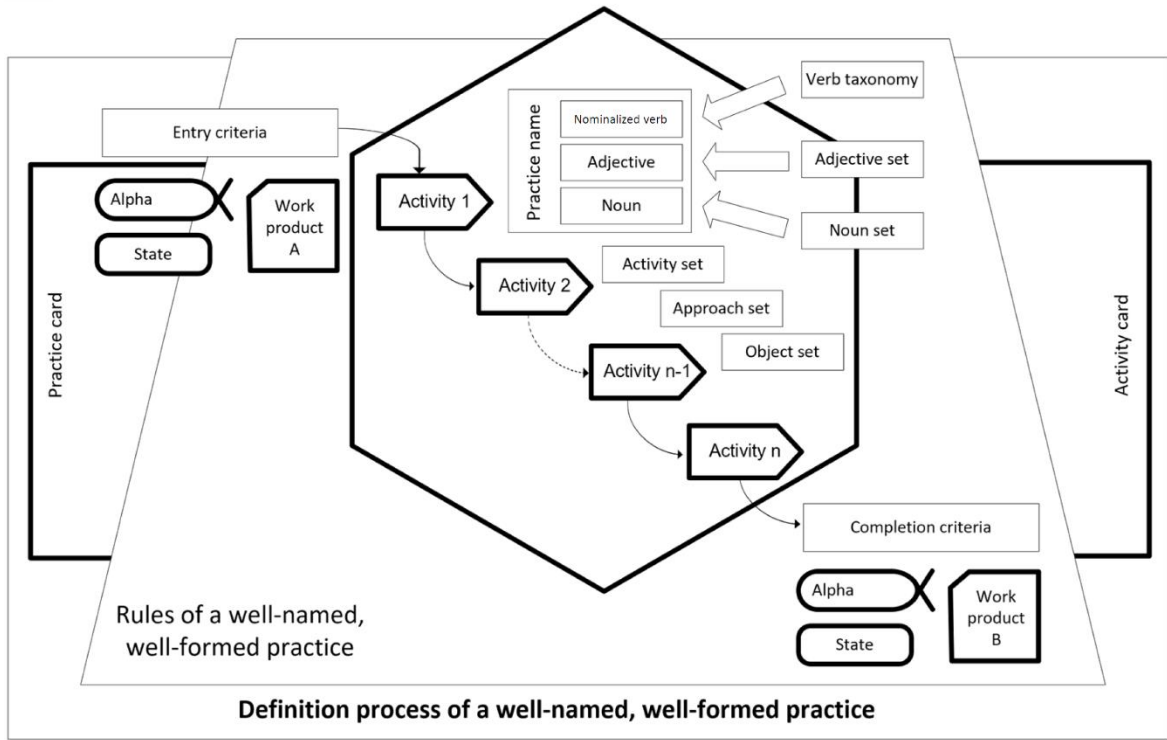


Figure 5-23: Definition process of a well-named, well-formed practice and characterization of a practice based on Barón (2019).

Utilizing the model of practice definition proposed by Barón (2019) necessitated the consolidation of previously identified verbs, nouns, and adjectives from our linguistic corpus. Currently, there is a comprehensive reference framework by IBE-UNESCO (2013), encompassing a glossary of terms pertinent to education and curriculum. Leveraging the insights gained through computational linguistics within our corpus, we began semantically associating the words identified from the linguistic corpus with IBE-UNESCO’s glossary terms. This process and its outcomes are depicted in Figure 5-24.

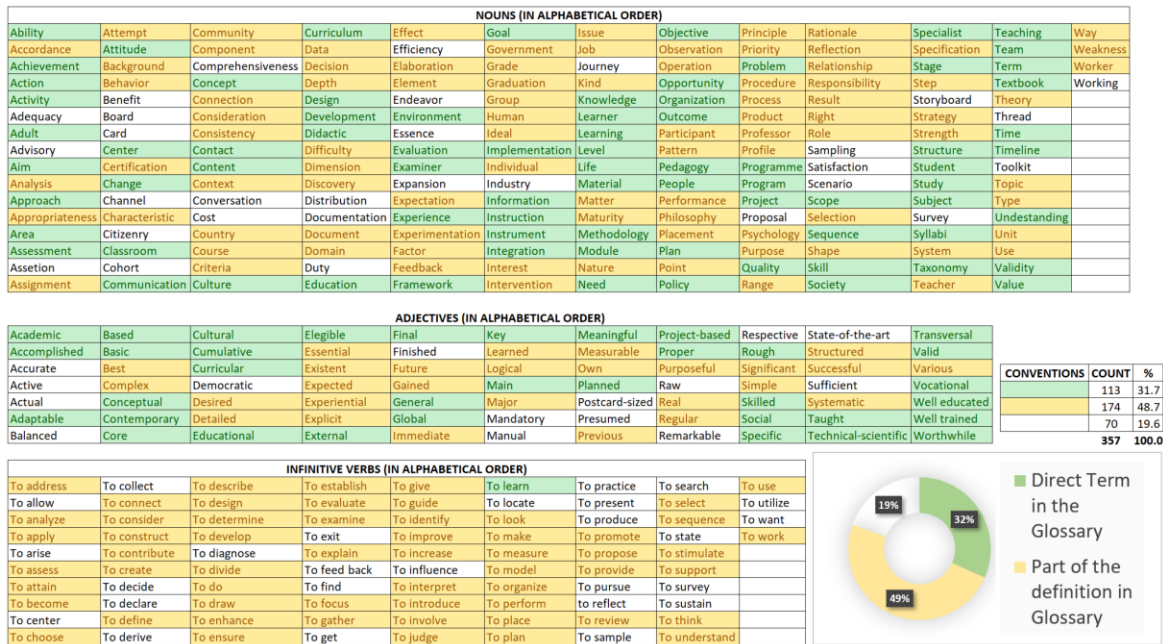
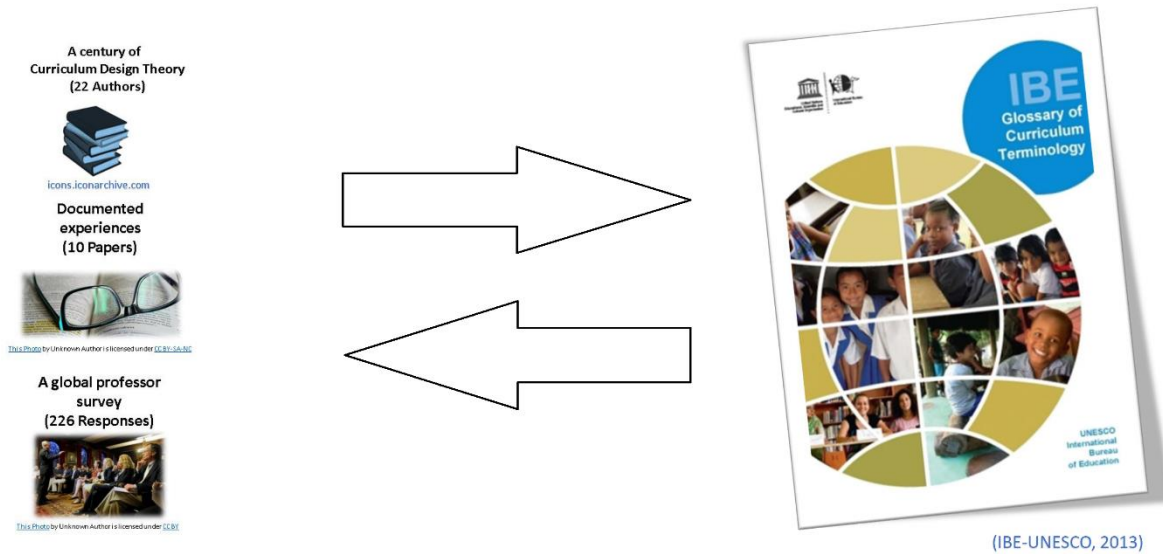


Figure 5-24: Process of semantic association based on ISO 704:2009.

According to the above, our research culminated in a glossary comprising 357 terms. Of these, approximately 32% are directly, explicitly, and textually present in the IBE-UNESCO glossary. About 49% of the identified terms have an implicit connection to the terms in the glossary. Lastly, 19% of terms discovered in the linguistic corpus are not featured in the IBE-UNESCO glossary, representing a unique contribution in this area.

5.5 Proposing modifications to the SEMAT Essence kernel

The Software Engineering Method and Theory (SEMAT) Essence standard represents a revolutionary approach to software engineering. Officially known as Essence – Kernel and Language for Software Engineering Methods, this standard, encapsulated in ISO/IEC 24774, offers a foundational framework for software development. Its primary aim is to provide a universal language and a common set of concepts that underpin all software engineering methods, thus promoting a more structured and consistent approach to software development. The SEMAT Essence standard is characterized by its ‘kernel,’ a collection of essential elements and practices inherent to all software development processes. These elements include software system, team, work, and way of working, each further divided into more specific practices and competencies. SEMAT Essence enables software engineers and organizations to efficiently assess and advance their methods and practices by providing a standardized structure. It also facilitates better communication and understanding among stakeholders by providing common terminology. This standard is considered a tool for improving software engineering practices, ensuring quality, and increasing the success rate of software development projects.

In line with its focus, SEMAT Essence operates within the realm of software engineering and acknowledges the ‘software system’ and the ‘opportunity’ as parts of its essential elements, or ALPHAs. This raises an intriguing question regarding the suitability and relevance of these definitions when applied to the field of curriculum design. Currently, we have two different scenarios, as depicted in Figure 5-25.



Figure 5-25: Comparing different scenarios.

Therefore, adopting a multidisciplinary perspective encompassing these diverse scenarios is essential. Consequently, we chose to modify the kernel to encompass a more expansive scenario that merged both software engineering and curriculum design. This broader scenario is project management, as both disciplines engage with the concept of a project to yield their respective outputs—software systems in the case of software engineering, and curriculum products—in the context of curriculum design. Figure 5-26 depicts the upper scenario of project management, in which the Quintessence kernel proposed by Henao (2018) is highly beneficial.

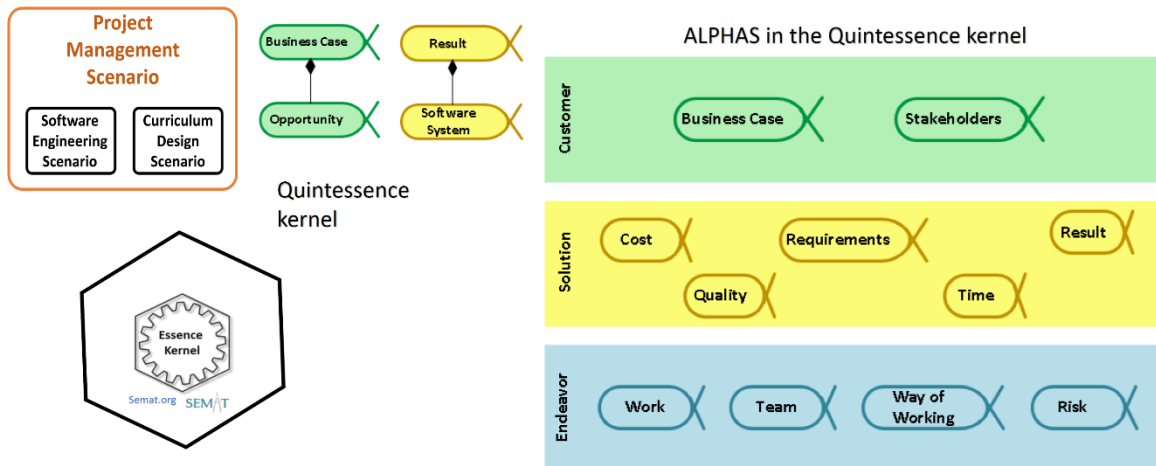


Figure 5-26: Quintessence kernel based on Henao (2018).

It recognizes that the Quintessence kernel is an advanced expansion of the SEMAT Essence kernel. Quintessence encompasses SEMAT Essence. As a result, engaging with Quintessence inherently involves working with SEMAT Essence simultaneously. We used the Quintessence kernel to ease language adaptation in educational scenarios. The Quintessence kernel for project management is grounded in ALPHAs, initially introduced by SEMAT Essence, a movement to establish a theoretical framework for software engineering. ALPHAs represent crucial project aspects that practitioners must focus on

during their execution. They serve as tools for managing and controlling the environment in which projects are conducted. ALPHAs are defined through various states, enabling the monitoring of the project's health and progress. Therefore, practitioners can pinpoint and address specific aspects of a project that need special attention during its implementation. Figure 5-27 depicts a structured representation of the Quintessence kernel using a pre-conceptual schema.

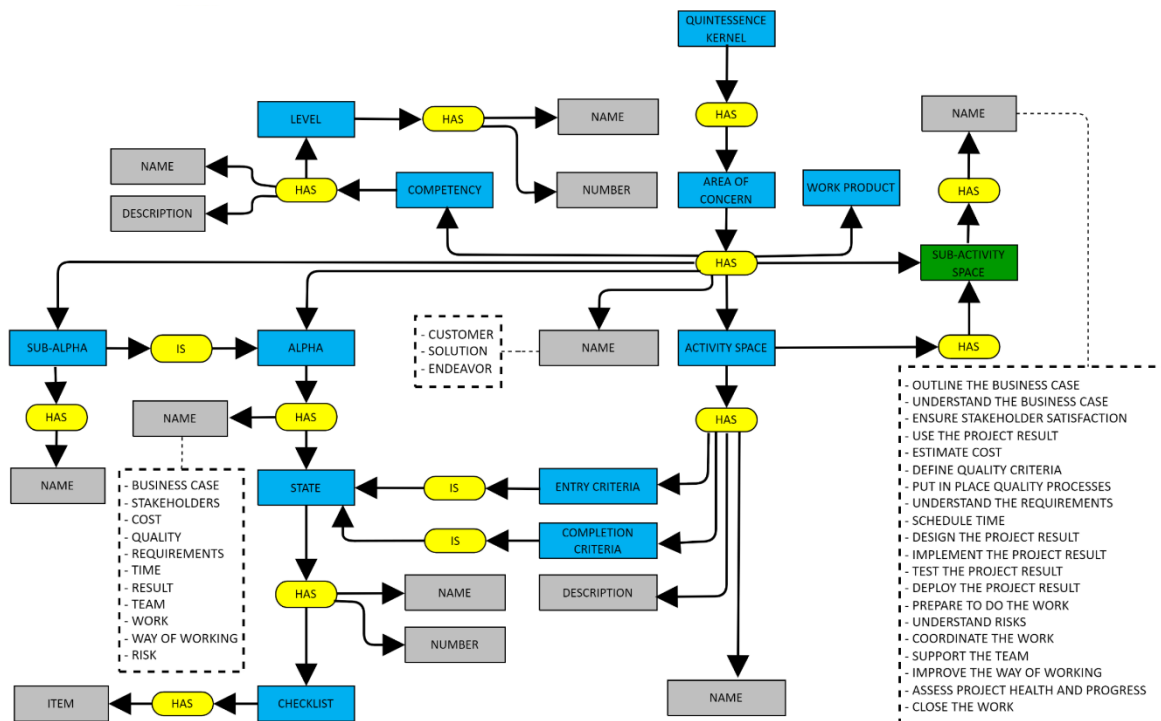


Figure 5-27: The Quintessence kernel based on Henao (2018).

To tailor the Quintessence kernel to educational settings, several key adaptations were essential:

- Introduction of two novel ALPHAs specifically for managing the aspects of curriculum and educational case.
- Removal of some ALPHAs that are not explicitly needed in the curriculum design scenarios.
- Integration of 10 common items for directing practices in curriculum design.
- Development of the skills required to tackle the complexities of designing a curriculum.
- Modification of the activity spaces to include tasks associated with curriculum design.

Thus, a novel kernel was formed, focusing specifically on aspects pertinent to curriculum design arising from linguistic analyses conducted on the corpus. This leads to the development of a new kernel, an adaptation from Quintessence called *EC-Nucleus*. The name *EC-Nucleus* is derived from the Latin phrase *Nucleus*, which directly means kernel. The representation of this adaptation is depicted in Figure 5-28.

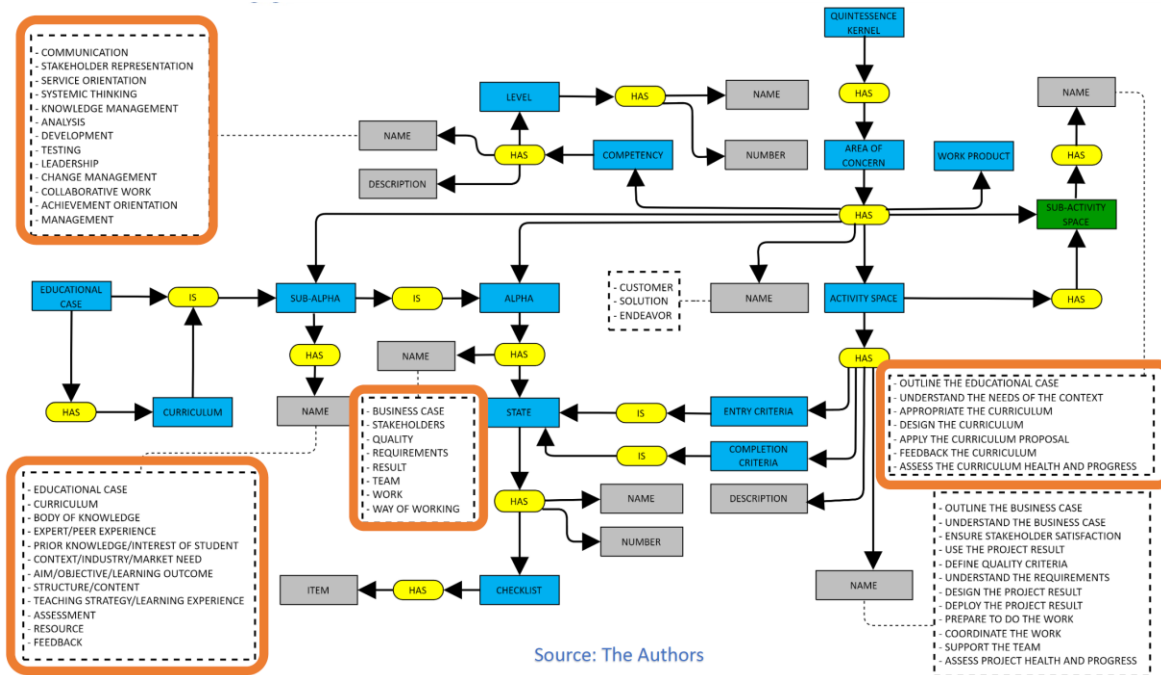


Figure 5-28: *EC-Nucleus* based on the Quintessence kernel.

Embracing the SEMAT Essence philosophy by adapting the Quintessence kernel in our *EC-Nucleus*, our initiative—named a Latin locution *ESSENTIA CURRICULUM*, which means ‘the essence of the curriculum’—concentrates on key educational components. It embodies the very fabric of constructing practices designed to cater to the changing requirements of learners and educational environments. This initiative mirrors the representation of practices in software engineering advocated by SEMAT Essence toward educational scenarios. It proposes transitioning to a curriculum design endeavor rooted in vital pedagogical tenets, allowing for innovative and context-specific modifications.

ESSENTIA CURRICULUM thus introduces its kernel, which includes ALPHAs, encompassing activity spaces, work products, and competencies, along with state machines that outline the progression of each ALPHA within the kernel. These components are illustrated in Figure 5-29. Inheriting the vision of SEMAT Essence, an ALPHA signifies a critical element needed to advance curriculum design in *ESSENTIA CURRICULUM*. The

ALPHAs track the development and status of the crucial elements required for a successful curriculum design outcome.

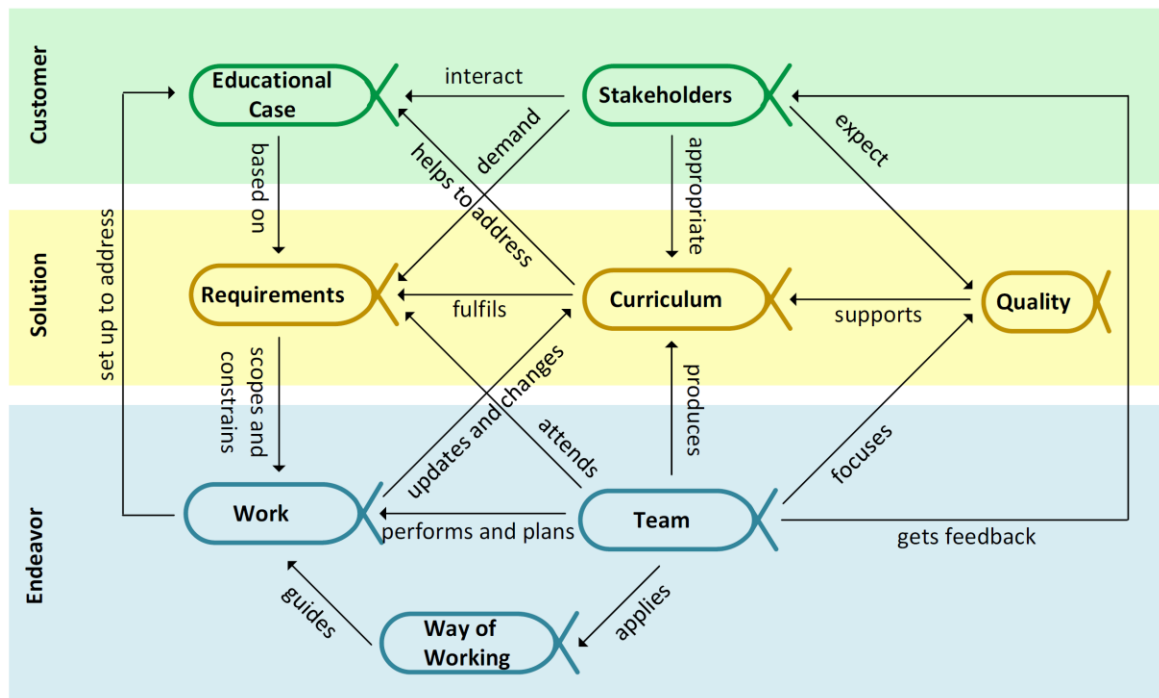


Figure 5-29: The Alphas in *ESSENTIA CURRICULUM*, inspired by OMG (2018) and Henao (2018).

Figure 4-29 highlights a conceptual model related to curriculum design within *ESSENTIA CURRICULUM*, inspired by the SEMAT Essence kernel—from the Quintessence perspective. Figure 4-29 is organized into three distinct sections, each marked with different colors to signify various stages or aspects of a process. At the top, the ALPHAs ‘Educational Case’ and ‘Stakeholders’ are linked by a two-way arrow, denoting interaction. A one-way arrow leads from ‘Stakeholders’ to ‘Quality,’ indicating the expectation of quality from stakeholders. ‘Educational Case’ is connected to ‘Requirements’ in the middle layer, with a two-way arrow showing that the educational case is both influenced by and influences these requirements. This middle section houses three ALPHAs—‘Requirements,’ ‘Curriculum,’ and ‘Quality,’ all interconnected, illustrating how ‘Requirements’ feed into ‘Curriculum,’ which supports ‘Quality.’ The arrows suggest that ‘Curriculum’ caters to ‘Requirements,’ while ‘Quality’ is focused on ‘Curriculum.’ The lower section contains three additional ALPHAs—‘Work, Team, and Way of Working,’ with the first two linked to denote that the team executes and plans. The third ALPHA directs the ‘Work’ and is implemented by the ‘Team,’ which also receives feedback on ‘Quality’ that influences the ‘Way of Working.’

Each ALPHA is interlinked with actions explicitly described on the connecting arrows. For instance, ‘Requirements’ define and limit ‘Work,’ while ‘Work’ updates and modifies ‘Requirements.’ Figure 5-29 visualizes a dynamic, interactive process in curriculum design, in which each element collaborates with others to ensure educational quality and effectiveness. It portrays a systematic method of integrating various facets of curriculum design, from stakeholder expectations to team efforts, all inspired by the flexible yet structured approach of the SEMAT Essence model.

Figure 5-30 details the set of ALPHAs in *ESSENTIA CURRICULUM*, illustrating the lifecycle and elements of curriculum design. This structure is organized into seven interconnected ALPHAs, each with progression stages depicted by rounded rectangles—states—on a vertical axis. Color-coded categories include Educational Case, Curriculum, Stakeholders, Requirements, Quality, Team, and Way of Working.

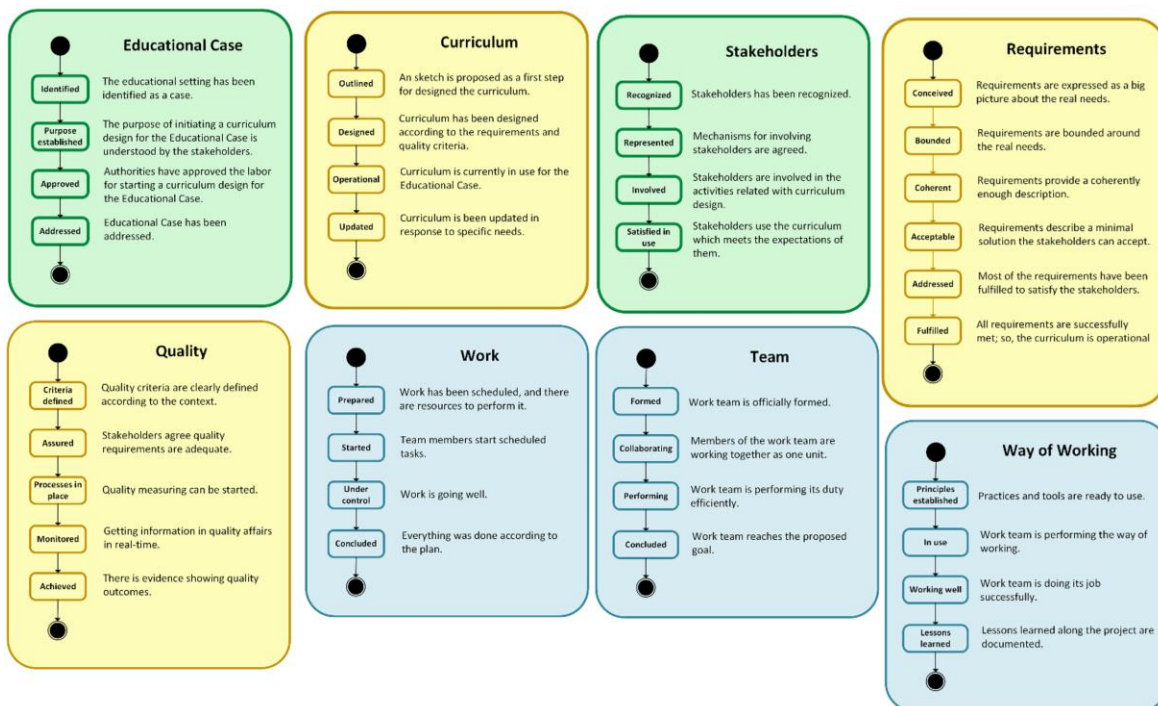


Figure 5-30: The ALPHAs and their states in *ESSENTIA CURRICULUM*, inspired by OMG (2018) and Henao (2018).

Each ALPHA encompasses a series of states that trace its progression from inception to completion.

- The Educational Case ALPHA focuses on grasping educational needs and the value of addressing these needs for learners and stakeholders. It concerns the purpose,

context, and rationale for starting a curriculum design project, considering its potential impact on learning environments and outcomes.

- The Stakeholders ALPHA is essential in curriculum design, monitoring the identification, involvement, and representation of all parties interested in educational outcomes, such as students, faculty, administrators, policymakers, and industry consultants. Integrating their needs, expectations, and feedback into the curriculum is crucial for its relevance and effectiveness.
- The Requirements ALPHA outlines what the curriculum must accomplish to meet the educational case and satisfy stakeholders. This includes defining learning objectives, content scope, pedagogical methods, assessment techniques, and compliance with accreditation or regulatory standards.
- The Curriculum ALPHA concentrates on the educational program's content, structure, and delivery methods, ranging from initial drafts to a fully functional curriculum ready for student engagement.
- The Work ALPHA represents the tasks involved in developing and implementing the curriculum, covering the planning, creation, execution, and revision of curriculum materials and activities and the administrative support required for the educational process.
- The Team ALPHA pertains to the groups collaborating on curriculum design and delivery, addressing the dynamics among curriculum designers, educators, and support staff, their roles, teamwork, and collective growth.
- The Way of Working ALPHA encapsulates the team's methodologies, practices, and tools in curriculum development and execution, emphasizing a reflective, iterative approach to enhance student learning.
- The Quality ALPHA mirrors the curriculum's standards and effectiveness in achieving its goals. It involves setting quality benchmarks, ensuring stakeholder satisfaction, applying assessment and feedback mechanisms, and continuously enhancing the curriculum based on results and feedback.

This comprehensive approach provides a detailed view of the stages and elements of curriculum development, focusing on an iterative, quality-centric process involving multiple stakeholders to ensure thorough and step-by-step coverage of each aspect. Given that ALPHAs represent consistent elements in curriculum design matters, they come with states that can be monitored to gauge their health and progress.

Figure 5-31 graphically depicts some activity spaces and competencies in the curriculum design process, structured into three main areas of concern, each indicated by a different color: customer (green), solution (yellow), and endeavor (blue). Each category comprises a set of activity spaces and competencies, conceptualizing curriculum design as a sequence of steps requiring specific task completion and the development of key competencies or values to accomplish the proposed work.

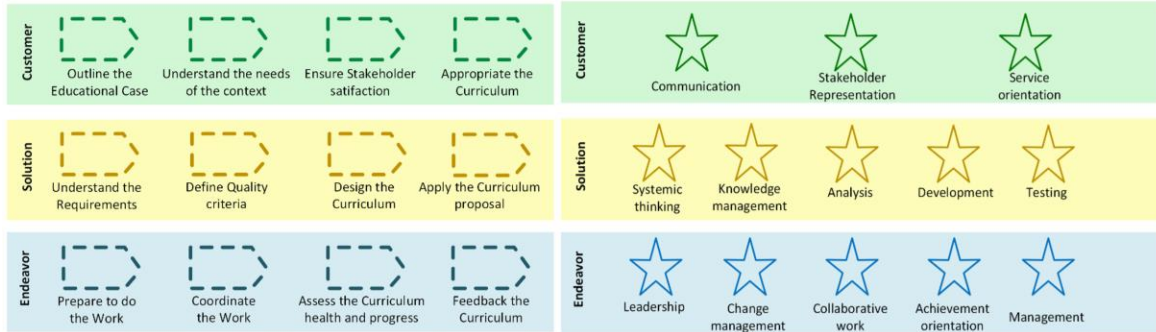


Figure 5-31: Activity spaces and competencies in *ESSENTIA CURRICULUM*, inspired by OMG (2018), Henao (2018), and Durango *et al.* (2019).

Figure 5-32 presents a structured outline of the work products involved in curriculum design. It visually links core elements such as ‘Requirements,’ ‘Curriculum,’ ‘Stakeholders,’ and ‘Way of Working,’ with lines suggesting relationships or flows between them.

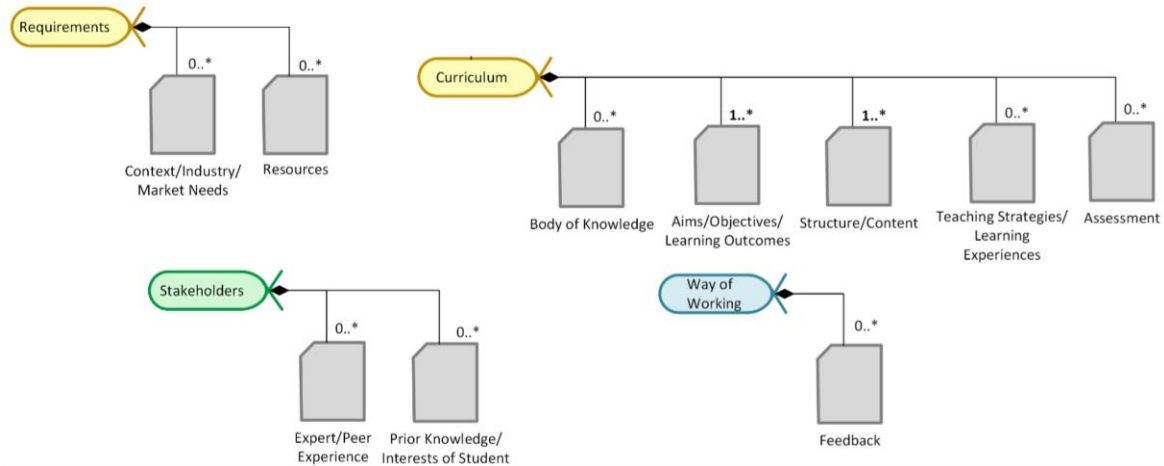


Figure 5-32: Work products in *ESSENTIA CURRICULUM*, inspired by OMG (2018).

- The Requirements ALPHA includes two work products, ‘Context/Industry/Market Needs’ and ‘Resources,’ representing the foundational needs and resources informing curriculum design, expressed in documents or artifacts, such as market

studies and surveys. These factors encompass job market demands, specific industry requirements, and available educational resources.

- The Curriculum ALPHA holds five work products—‘Body of Knowledge,’ ‘Aims/Objectives/Learning Outcomes,’ ‘Structure/Content,’ ‘Teaching Strategies/Learning Experiences,’ and ‘Assessment,’ also expressed as documents or artifacts, which may include syllabi, educational plans, curriculum methodologies, and pedagogical models. These products cover various dimensions essential to curriculum development, including imparted knowledge, expected learning outcomes, content organization, delivery methods, and student assessment strategies.
- The Stakeholders ALPHA involves two work products: ‘Expert/Peer Experience’ and ‘Prior Knowledge/Interests of Student,’ recognizing the significance of considering educators’ and peers’ experiences and learners’ backgrounds and interests in curriculum design. Such documents could result from consultations with peers or surveys of applicants enrolling in academic programs.
- The Way of Working ALPHA has a single work product, ‘Feedback,’ highlighting the importance of incorporating feedback into the curriculum development process to meet the needs of both educators and learners. The associated documentation here is the self-assessment report for academic program accreditation.

In this study, we gathered all the necessary inputs to put forward a proposed initiative that builds upon the insights provided by applying computational linguistics to the corpus. This led to the *ESSENTIA CURRICULUM* initiative, which encompasses a kernel and a language specification based on the kernel.

Language specification plays a pivotal role in computer science and linguistic theory as a foundational tool for defining the syntax and semantics of programming languages and various forms of communication. Sometimes, a language specification employs precise mathematical models to describe the structure of language constructs, ensuring unambiguous interpretation and implementation. One way of specifying a language is to use pre-conceptual schemas. Pre-conceptual schemas utilize controlled language to depict actors, concepts, values, conditionals, implications, and static and dynamic relationships. This approach enables the representation of any knowledge structure through pre-conceptual schemas (Insuasti *et al.*, 2023). Figure 5-33 depicts a pre-conceptual schema of the language specification of *ESSENTIA CURRICULUM*.

The curriculum is a central component, represented as a conceptual entity that is both background-based and component-based, each with its own approach count. Authors of the curriculum engage in activities such as proposing, using, describing, defining, and applying, indicative of their multifaceted role in curriculum development. Designers are also linked with the act of defining, signifying their contribution to the structure and content of the curriculum. Practitioners are tasked with applying these designs and translating theoretical frameworks into practical educational scenarios.

Educational cases within the curriculum provide a structured approach to learning, incorporating communication, stakeholder representation, systemic thinking, knowledge management, and various other competencies. These competencies mean that they are comprehensive, coherent, consistent, and substantial enough to guide curriculum designers. The curriculum is further enriched by elements such as pedagogy, theory, method, and practice, which are interconnected and elevate the educational experience to its highest quality.

ESSENTIA CURRICULUM, an overarching structure within the curriculum based on the Quintessence kernel, captures the essence of the educational endeavor in curriculum design, focusing on areas of concern, competencies, and work products that are vital for the curriculum's success. Activities and sub-activities within the kernel outline the business case, ensuring stakeholder satisfaction, understanding the business case, defining quality criteria, understanding requirements, designing the product, deploying the product, and coordinating the work—all of which are critical for maintaining the health and progress of the ALPHAs involved.

Each element and action within *ESSENTIA CURRICULUM* is methodically interconnected, forming a cohesive system that outlines the business case, understands stakeholders' needs, and delivers a curriculum that meets educational and quality standards. This systematic process ensures that every curriculum component is carefully considered and integrated, resulting in a robust and effective educational program. Ultimately, *ESSENTIA CURRICULUM* constitutes the proposed solution as a model formed by its kernel and language specification, as depicted in Figure 5-34, establishing common ground in curriculum design affairs.

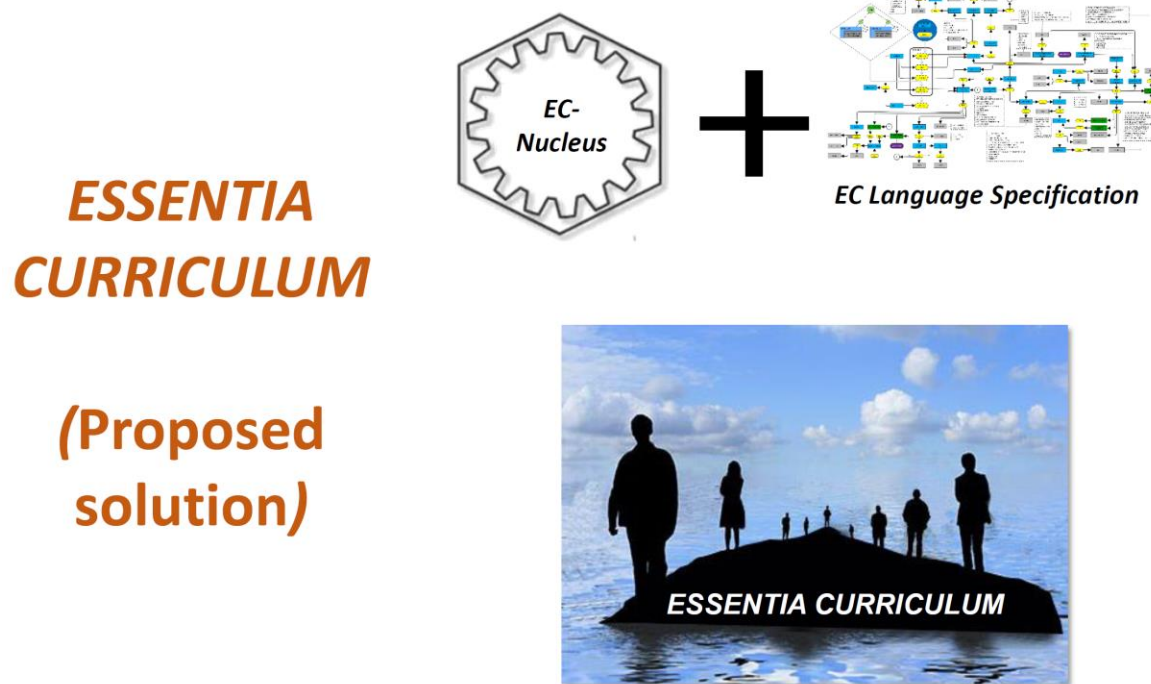


Figure 5-34: *ESSENTIA CURRICULUM* as the model formed by its kernel and language specification.

5.6 Representing common practices in *ESSENTIA CURRICULUM*

Considering the kernel and the language specification of *ESSENTIA CURRICULUM*, we have arrived at a stage at which we can apply these conceptual models in real-world settings to illustrate curriculum design endeavors. By employing the kernel and language specification of *ESSENTIA CURRICULUM*, we successfully depicted 10 common curriculum design practices that encapsulate the spirit behind the *ESSENTIA CURRICULUM* method in Figure 5-35. This demonstrates the model's capacity to uniformly capture any practice within the realm of curriculum design, regardless of context.

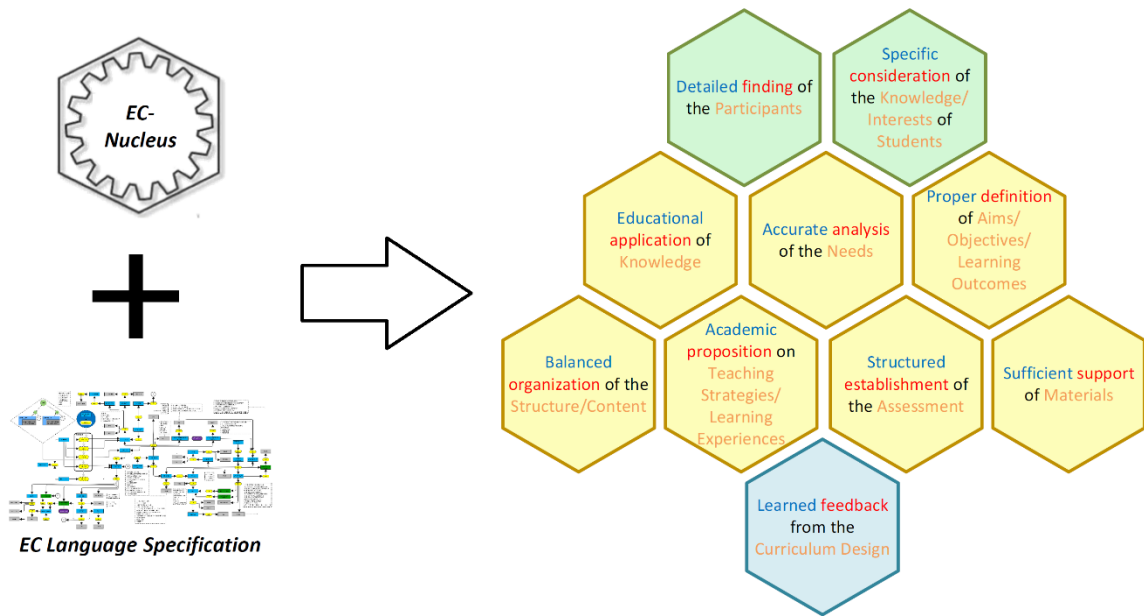


Figure 5-35: 10 common practices represented in the *ESSENTIA CURRICULUM* method.

The very spirit of the *ESSENTIA CURRICULUM* method states that all curriculum design practices can be equivalently represented through the use and adaptation of these 10 common practices. This declaration agrees with the fundamental principle of privileging the freedom of practices instead of promoting the methods that contain said practices, as stated by Jacobson and Stimson (2018):

The problem is that the professional practices developed and refined over many years and representing our shared industry knowledge and experience are often imprisoned within proprietary method jails. The only option that development organizations and teams see themselves as having is to adopt this method or that method wholesale and to reject all others—whereas what is needed is for organizations and teams to be free to select the professional practices that they need from wherever these may be defined, and use them in whatever permutations and combinations are appropriate to meet the exact set of circumstances and challenges they face.

Just as this innovative thinking has taken root in software engineering, a similar circumstance is found in curriculum design within education scenarios. Whereas the literature review of a century of studies on curriculum design theory reveals numerous methods, empirical application in real-world scenarios has shown a restrained utilization of the methods proposed by the theory. In this context, the specific practices of these methods gain significance, especially as *ESSENTIA CURRICULUM* introduces 10 common

practices that are adept at characterizing any curriculum design method, as described by common practices 1–10 and illustrated in Figures 5-36 to 5-45.

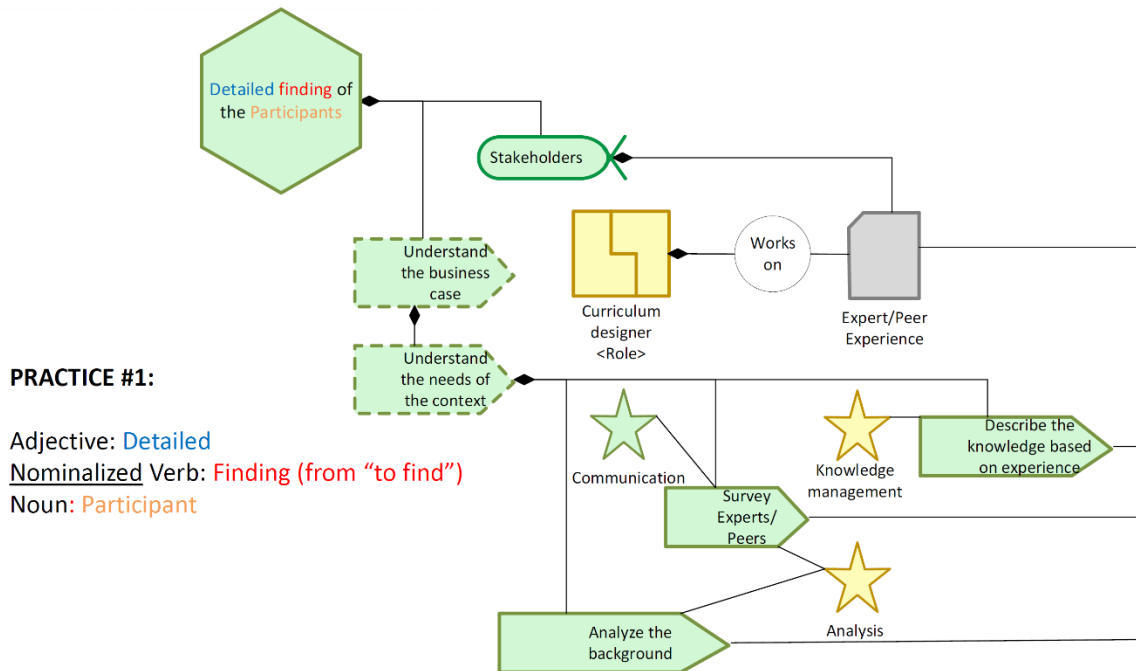


Figure 5-36: Common practice 1 – Detailed finding of the participants.

Figure 5-36 depicts the practice of the “detailed finding of the participants.” The curriculum design process commences considering the stakeholders involved in the curriculum design effort, emphasizing the importance of grasping both the business imperatives and the contextual needs that the curriculum aims to fulfill. The curriculum designer, a pivotal agent in this process, synthesizes insights from the business case and contextual understanding to inform the development of the curriculum. Integral to this process is incorporating expert and peer experiences, which the curriculum designer meticulously assimilates through systematic surveys. This engagement with seasoned professionals enriches the curriculum and ensures its alignment with industry standards and educational efficacy. Concurrently, knowledge management and analytical activities are conducted to process and interpret the data gathered, fostering a robust foundation for the curriculum. The culmination of this practice involves two key communication outputs: the dissemination of findings regarding participant analysis and the articulation of knowledge predicated on aggregated experiences. This systematic approach underpins the curriculum with a nuanced understanding of participant dynamics, ensuring that the resultant educational framework is comprehensive and responsive to the defined educational objectives.

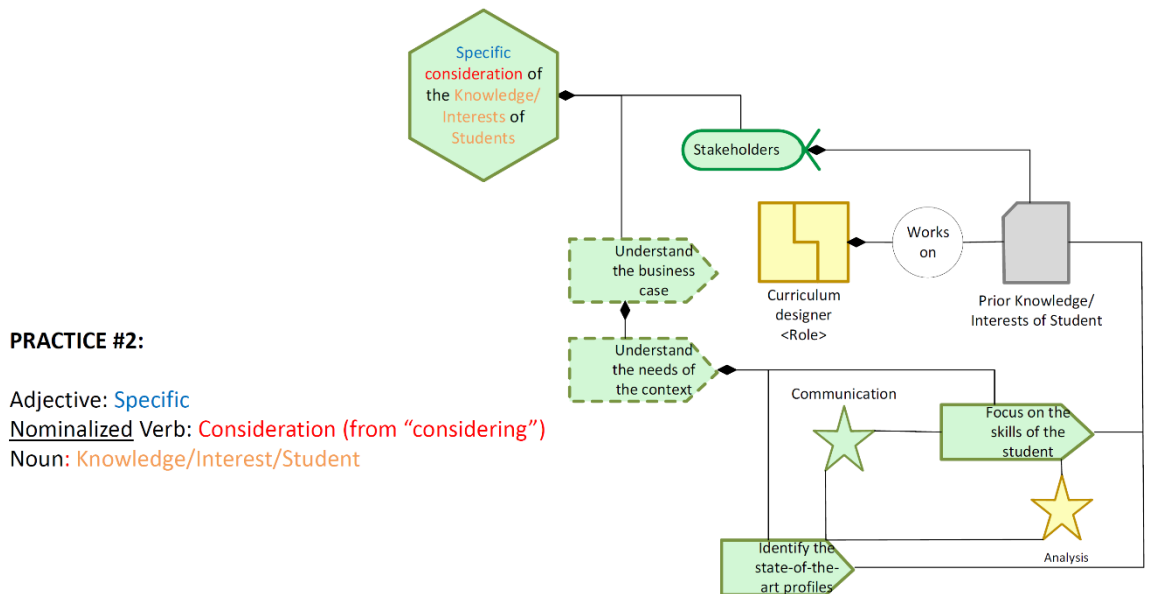


Figure 5-37: Common practice 2 – Specific consideration of the knowledge/interests of students.

In the curriculum design process, “specific consideration of the knowledge/interests of students” constitutes a practice that underscores the necessity of tailoring educational content to meet the unique needs and curiosities of the student body. This practice, depicted in Figure 5-37, initiates a comprehensive understanding of the stakeholders involved, delving into an acute awareness of the business case and the broader context’s demands. Central to this practice, the curriculum designer meticulously integrates students’ prior knowledge and interests into the curriculum framework, acknowledging that these elements are critical for student engagement and learning outcomes. Communication channels are established to ensure that the curriculum resonates with the student’s academic and professional aspirations. Furthermore, the practice involves a thorough analysis facilitated by identifying state-of-the-art student profiles, which aids in centering the curriculum on developing student competencies. The specificity of this practice lies in its commitment to aligning educational objectives with evolving educational and vocational landscapes, thus fostering a curriculum that reflects current industry trends and supports each student’s learning journey.

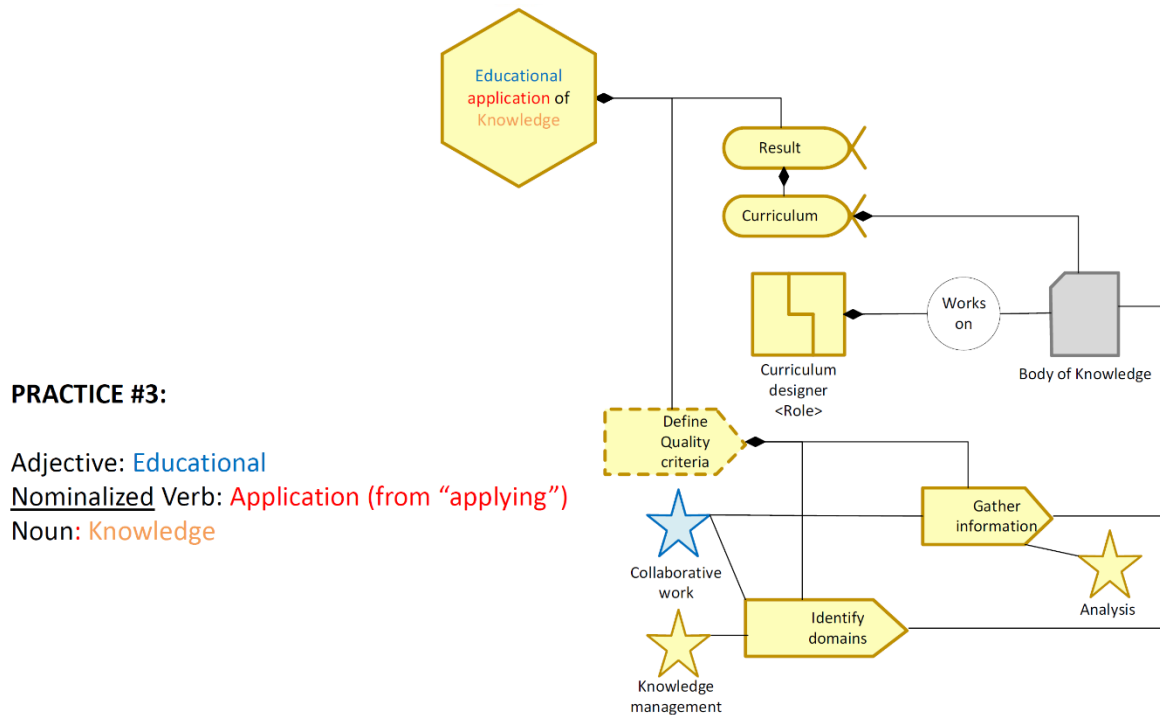


Figure 5-38: Common practice 3 – Educational application of knowledge.

Figure 5-38 depicts the practice of the “educational application of knowledge” in curriculum design. It underscores the transformative process of applying theoretical knowledge in educational settings. This practice is initiated by the curriculum designer, whose role is pivotal in translating abstract concepts into tangible learning outcomes. The designer is tasked with defining quality criteria, ensuring that the curriculum not only imparts knowledge but does so to a standard of excellence that benefits the learner’s comprehension and capability. Central to this endeavor is the body of knowledge, which serves as the foundation upon which the curriculum is constructed and upon which the designer works. Collaborative work and knowledge management emerge as key activities in operationalizing this practice. The curriculum designer orchestrates efforts to gather information and identify relevant knowledge domains, fostering an environment in which collaborative input is leveraged to enrich the curriculum. Through systematic analysis, the practice involves distilling complex information into educational content that is both accessible and applicable to students.

The “educational application of knowledge” is a dynamic interplay between the curriculum’s conceptual framework and practical pedagogy, with the curriculum designer acting as the fulcrum, balancing the need for rigorous academic standards with the pragmatic

requirements of educational efficacy. This approach ensures that the resultant curriculum is not merely a repository of information but a gateway to the practical application of knowledge in real-world contexts.

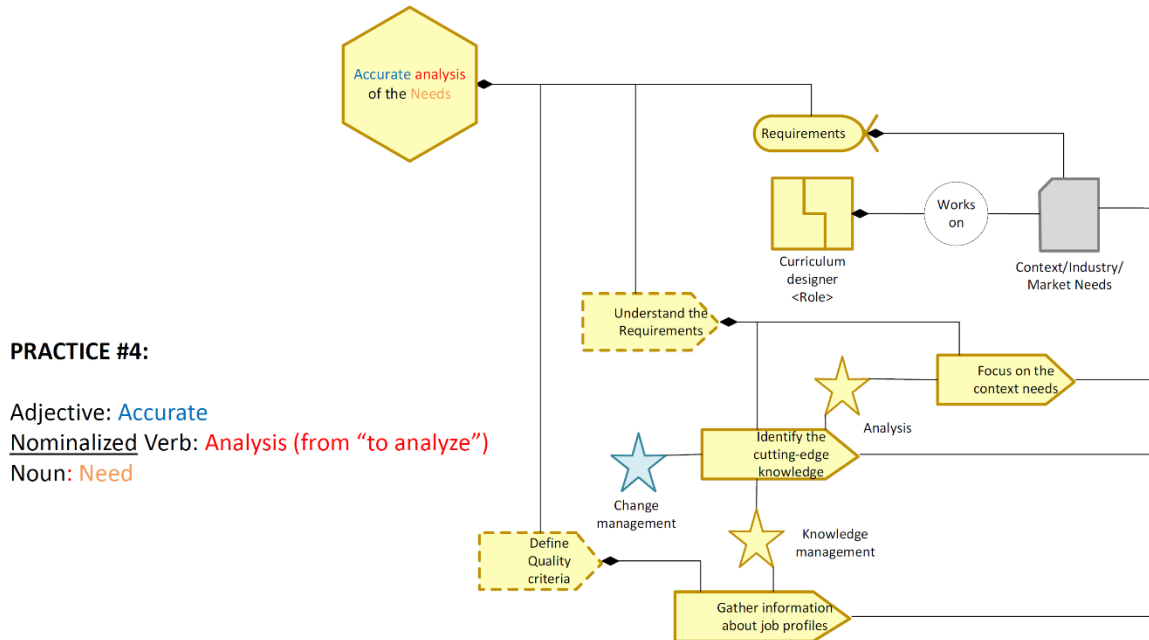


Figure 5-39: Common practice 4 – Accurate analysis of the needs.

The practice depicted in Figure 5-39 about “accurate analysis of the needs” in curriculum design is critical to ensuring that the educational offerings are closely aligned with the context, industry, or market demands. The curriculum designer occupies a central role in this analytical process, in which a detailed understanding of the requirements is paramount. By examining the educational landscape, the designer is tasked with defining quality criteria that serve as benchmarks for curriculum effectiveness. This meticulous analysis extends to a keen focus on the specific needs of the context in which the curriculum will be applied. The designer can integrate contemporary expectations into the curriculum by identifying innovative knowledge and assimilating up-to-date job profiles. Change management becomes essential, allowing the curriculum to remain relevant and responsive to evolving industry standards and market dynamics.

The practice involves a systematic approach to knowledge management, in which gathered information is carefully curated and evaluated. This ensures that the curriculum meets current requirements and is poised to adapt to future changes. By focusing on the context needs through rigorous analysis, the practice ensures that the curriculum is academically

sound and pragmatically valid, bridging the gap between educational aspirations and real-world applications.

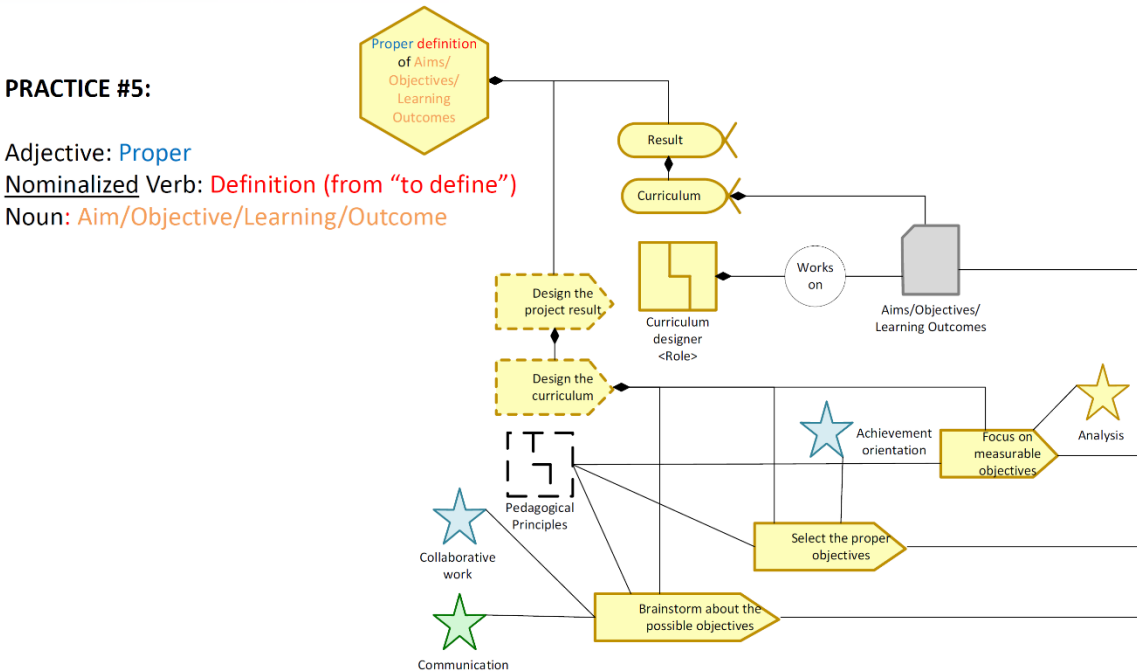


Figure 5-40: Common practice 5 – Proper definition of aims/objectives/learning outcomes.

Figure 5-40 describes the practice of the “proper definition of aims/objectives/learning outcomes” as an integral part of formulating a targeted and outcome-driven curriculum. This practice is characterized by a structured approach in which the curriculum designer rigorously defines what the educational program seeks to achieve. It begins with the designer working on the curriculum, drawing from pedagogical principles to ensure that the aims, objectives, and learning outcomes reflect educational best practices.

Collaborative work and effective communication are foundational to this process, facilitating a brainstorming environment in which potential objectives are explored and refined. The emphasis on selecting the proper objectives is central to this practice, pointing to a meticulous process of sifting through goals to identify those that best align with the curriculum’s intended results. An analysis phase follows, where these objectives are scrutinized to ensure they are measurable and achievement-oriented, which is crucial for the subsequent evaluation of the curriculum’s effectiveness.

Through this practice, the curriculum designer ensures that the educational goals are clearly articulated and capable of guiding the learning journey precisely and practically. The

focus on measurable objectives allows for continuous assessment and refinement of the curriculum, ensuring that it remains aligned with both academic standards and the learning needs of students.

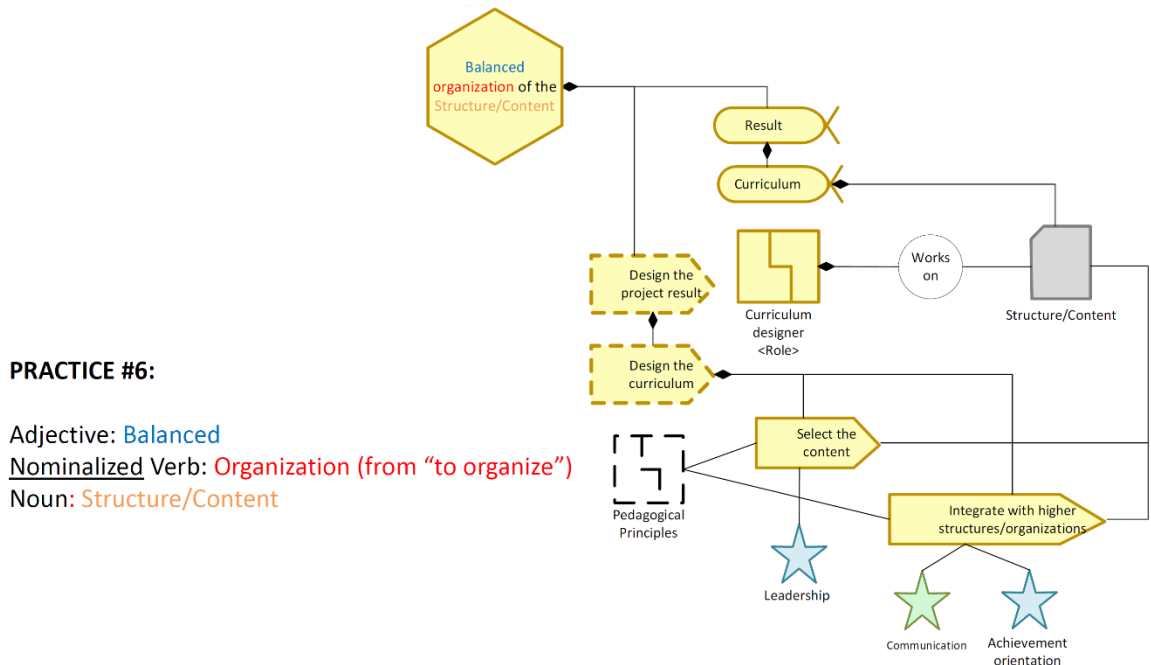


Figure 5-41: Common practice 6 – Balanced organization of the structure/content.

The practice depicted in Figure 5-41 about “balanced organization of the structure/content” within curriculum design is an essential strategy that involves a systematic approach to arranging educational content. This process is steered by the curriculum designer, whose role is to construct the curriculum to achieve a harmonious composition of its structure and content. Grounded in pedagogical principles, the designer orchestrates the curriculum’s framework, ensuring that the content selection is purposeful and coherent.

Leadership plays a critical role in this practice, guiding the selection of relevant content that aligns with overarching educational goals. Moreover, the practice involves integrating this content with higher-level structures or organizations, suggesting a need for alignment with broader educational standards and institutional objectives.

This balanced organization is not solely a matter of content arrangement but also fosters communication and achievement orientation within the curriculum development team. The result is a curriculum that delivers well-structured and logical educational material and supports learning outcomes in a way that is cohesive with the institution’s educational mission and the learners’ needs.

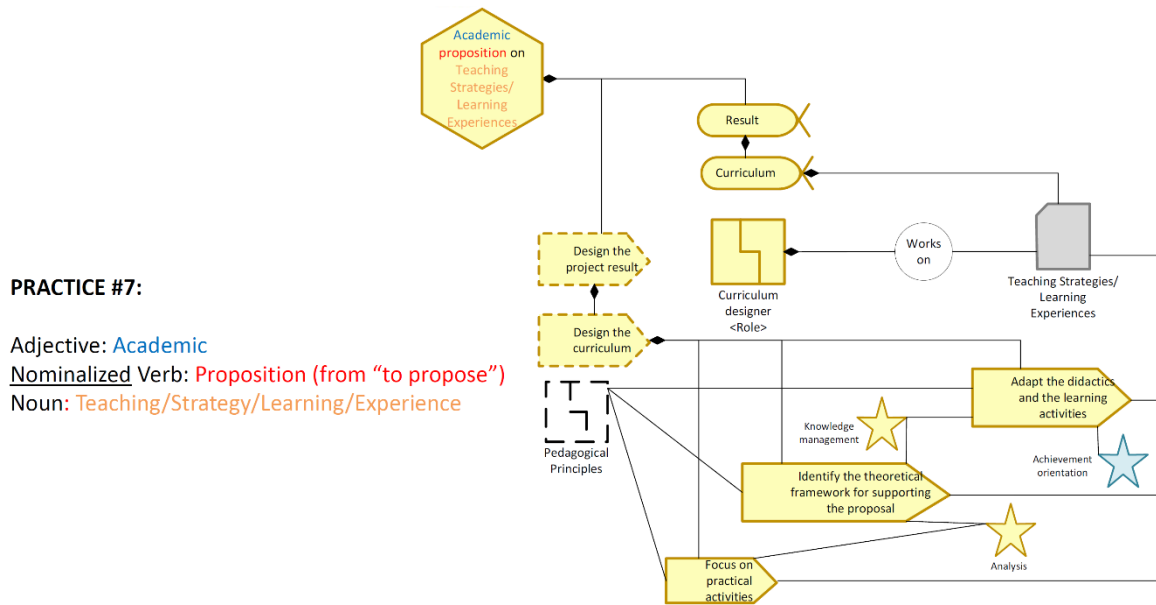


Figure 5-42: Common practice 7 – Academic proposition on teaching strategies/learning experiences.

Figure 5-42 depicts the practice of “academic proposition on teaching strategies/learning experiences” within curriculum design, a reflective and strategic approach to enhancing educational delivery. This academic endeavor begins with the curriculum designer, who is instrumental in shaping the project’s outcomes and curriculum. The focus is on crafting a pedagogical blueprint informed by scholarly principles and responsive to effective teaching and learning requirements.

The curriculum designer’s engagement with teaching strategies and learning experiences is central to this practice. The designer is responsible for working on these aspects, ensuring that they are adapted to meet the educational goals and the learners’ needs. This involves a dual focus: first, on the practical activities that will form the core of the educational experience, and second, on the adaptation of didactics to enhance the learning activities, ensuring that they are achievement-oriented and aligned with the curriculum’s aims.

The process is underpinned by knowledge management and a thorough analysis to identify the theoretical framework that supports the proposition, thereby grounding the curriculum in a robust academic context. This ensures that the proposed teaching strategies and learning experiences are theoretically sound and applicable, leading to a curriculum that facilitates meaningful and effective learning outcomes.

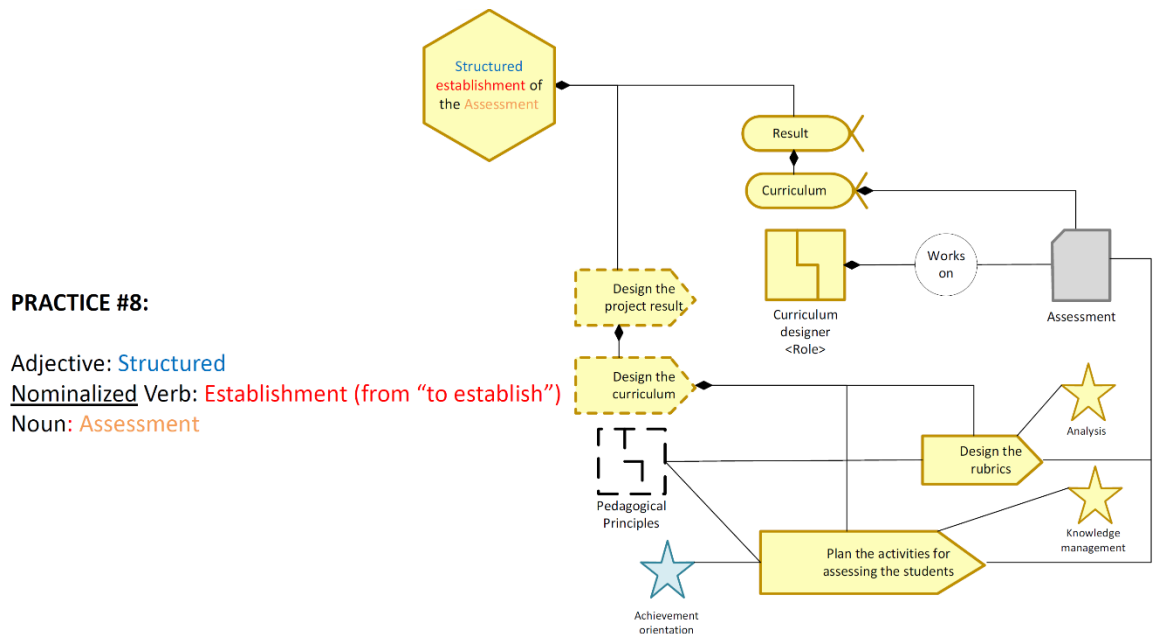


Figure 5-43: Common practice 8 – Structured establishment of the assessment.

Figure 5-43 depicts the practice of a “structured establishment of the assessment,” which constitutes a systematic approach to evaluating student performance and learning within the curriculum design framework. This practice entails the curriculum designer’s key role in shaping educational outcomes and the curriculum, focusing on ensuring that assessment methodologies are systematically developed. The foundation of this practice is rooted in pedagogical principles that guide the curriculum design and underpin the assessment’s structure.

Critical to this structured approach is the development of rubrics, which provide clear criteria for evaluating student work. These rubrics integrate thorough analysis and knowledge management, ensuring that the assessment criteria align with the curriculum’s learning objectives and outcomes. Alongside the design of rubrics is the planning of activities for assessing students, which is essential for operationalizing the rubrics in a classroom setting.

By emphasizing achievement orientation, the curriculum designer ensures that the assessment methods are aligned with educational goals and facilitates the measurement of student achievement clearly and objectively. This structured establishment of assessment processes serves as a backbone for a curriculum that is not only academically rigorous but also capable of providing meaningful feedback on student learning, thereby supporting continuous improvement in teaching and learning strategies.

PRACTICE #9:

Adjective: **Sufficient**

Nominalized Verb: **Support (from "to support")**

Noun: **Material**

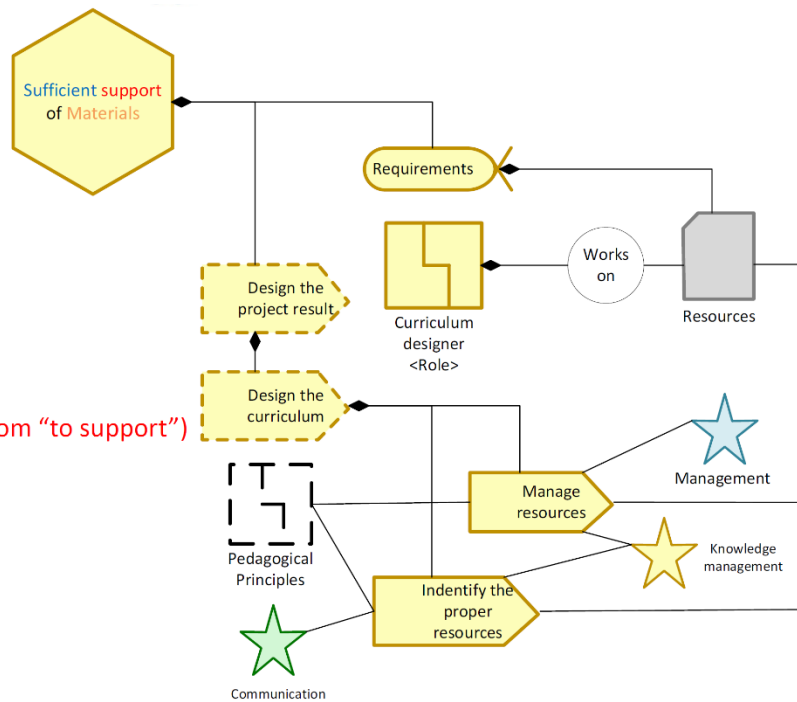


Figure 5-44: Common practice 9 – Sufficient support of materials.

As shown in Figure 5-44, “sufficient support of materials” in curriculum design emphasizes the importance of providing adequate resources to facilitate the educational process. This practice is characterized by the curriculum designer’s initiative-taking role in ensuring that the curriculum is supported by the necessary materials, which are selected based on pedagogical principles and the specific requirements of the curriculum.

The process involves a strategic approach to resource management, in which the curriculum designer works to identify and manage the materials that best support the curriculum objectives. Through effective communication and knowledge management, the designer identifies the proper resources, ensuring that they are not only aligned with the curriculum’s goals but are also readily available and accessible to both educators and learners.

Resource management within this practice is not just about the quantity of materials but also about their relevance and quality, ensuring that the curriculum is robustly supported. This structured support is crucial for successfully delivering the curriculum, enabling learners to engage meaningfully with the material and achieve the desired learning outcomes.

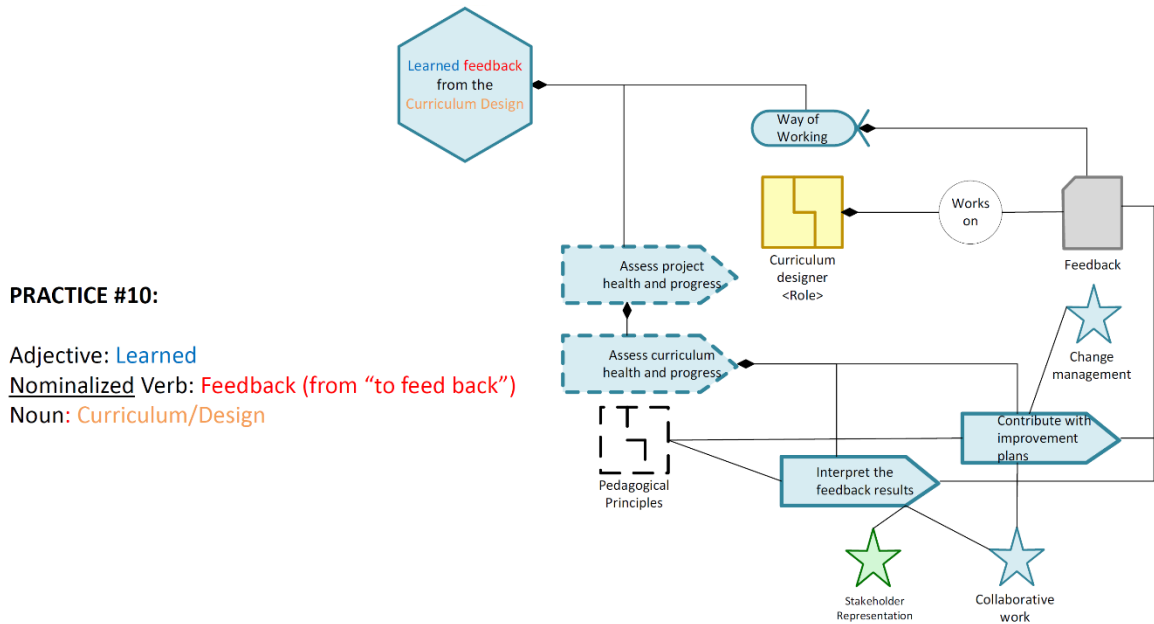


Figure 5-45: Common practice 10 – Learned feedback from the curriculum design.

Figure 5-45 depicts the practice of “Learned Feedback from the Curriculum Design,” which reflects a cyclical, reflective process essential for the continuous improvement of educational programs. This practice involves the curriculum designer, who plays a critical role in assessing the current state of the curriculum and implementing changes based on feedback. The assessment is twofold: the overall health and progress of the project and the specific health and improvement of the curriculum itself.

Underpinned by pedagogical principles, the curriculum designer evaluates feedback within educational best practices. This feedback, derived from various sources, including stakeholders and the curriculum’s application, is meticulously analyzed to interpret its implications for the curriculum. Change management is a key component of this practice; here, feedback is not simply collected and reviewed but is actively used to contribute to improvement plans.

Through collaborative work, the curriculum designer and stakeholders collectively interpret feedback results and devise strategies for enhancement. This approach ensures that the curriculum remains dynamic, responsive to feedback, and aligned with pedagogical standards and learners’ evolving needs. Integrating learned input into the curriculum design process thus becomes a cornerstone for fostering an adaptive, effective educational environment.

5.7 Forming a library of practices represented in ESSENTIA CURRICULUM

Initially, with these 10 common practices and involving the production of practices proposed by the community, a base library of practices represented in *ESSENTIA CURRICULUM* is established. We call the library *EC-Bibliotheca*. The word *Bibliotheca* is a Latin locution meaning a set of books or a library.

EC-Bibliotheca utilizes modern technology to create an online digital repository that houses a collection of curriculum design examples from its community. This initiative is organized via its official website, <https://essentiacurriculum.net/index.php/essentia-curriculum-library-ec-bibliotheca/>, which also facilitates the process of contributions by allowing individuals to sign up and participate as contributors to this initiative. This digital platform is designed to continually expand its resources through these community contributions by using *ESSENTIA CURRICULUM* to represent curriculum designs. Figure 5-46 depicts *EC-Bibliotheca* as a digital repository.

Thus, *EC-Bibliotheca*, which was initially formed by 10 base practices, is growing as it is enriched by the contributions of the community that uses *ESSENTIA CURRICULUM*. That is, *EC-Bibliotheca* starts with 10 fundamental practices for curriculum design, but such a library grows due to the contributions of others.

EC-Bibliotheca: available at <https://essentiacurriculum.net/index.php/essentia-curriculum-library-ec-bibliotheca/>

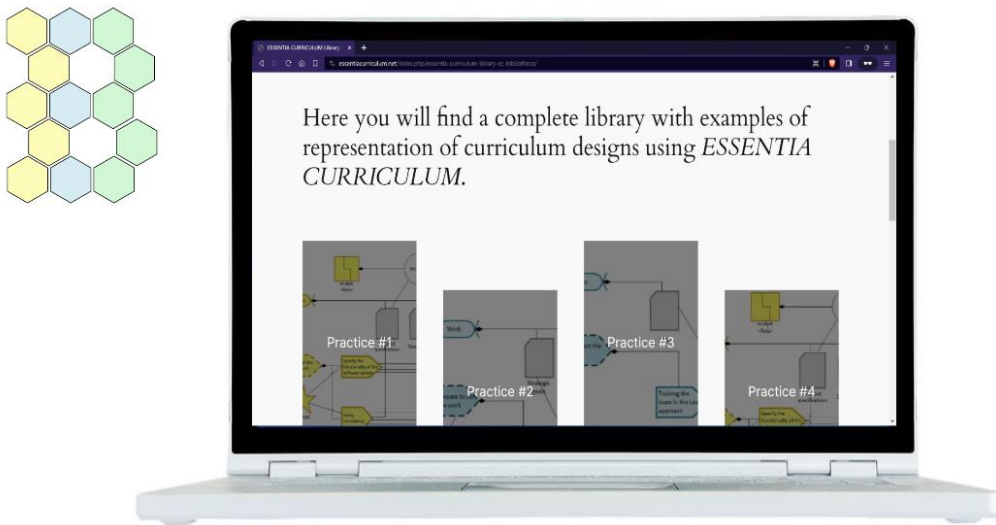


Figure 5-46: *EC-Bibliotheca* as a digital repository.

To effectively engage academics and practitioners in the field of curriculum design with *ESSENTIA CURRICULUM* and *EC-Bibliotheca*, an appropriation strategy can focus on highlighting the collaborative and dynamic nature of the repository.

In the ever-evolving landscape of education, the need for dynamic and adaptive curriculum frameworks has never been more critical. Recognizing this imperative, our digital library of curriculum design practices called *EC-Bibliotheca* serves as a pioneering platform that not only catalogues the ten foundational practices identified through rigorous research but also empowers the academic and practitioner community to contribute and refine these practices. This repository is designed not just as a resource but as a community hub, where the collective expertise of educators can be leveraged to foster innovative curriculum designs that meet contemporary educational demands.

The participation of academics and practitioners is vital to the vitality and relevance of this repository. By contributing to the *EC-Bibliotheca*, curriculum designers are not only sharing their expertise with a global audience but also engaging in a continuous process of learning and development. The platform facilitates an interactive exchange of ideas, allowing users to comment on, modify, and improve existing practices as well as to submit new ones. This ongoing interaction ensures that the repository remains at the cutting edge of curriculum design, continuously evolving with the changing educational landscapes.

We propose a “2nd Call for Action” in order to invite all stakeholders in the field of education—curriculum designers, teachers, professors, educational leaders, and policy makers—to join this collaborative endeavor. By participating, people help ensure that the repository grows in richness and applicability, becoming an invaluable tool for anyone involved in curriculum planning and implementation. Curriculum designers’ contributions will not only enhance their professional development but also have a profound impact on educational practices worldwide.

According to above, we start a “2nd Call for Action” in the same way as the first one. We will initially use communication via email invitation to participate in this way of initially feeding the library with the same emails from the 226 professors who participated in the survey. Some of these aspects are mentioned in the future work section of this document

6. Verification and validation

Leonardo Mangeruca has made significant contributions to the verification and validation field, particularly in aerospace systems engineering. According to Mangeruca (2017), verification and validation are crucial concepts in systems engineering, software development, and various technical fields, often used to ensure that a system or component meets its specifications and intended purpose. Both verification and validation terms are clearly defined in IEEE 1012-2016. Considering the standard, verification and validation are two different but interrelated concepts.

Verification assesses whether a system or component conforms to specific requirements or specifications. This is often an internal process that answers, “Are we building the product right?” Verification involves technical reviews, inspections, and testing methods to ensure that the system or component is developed correctly according to the design specifications. Conversely, validation evaluates a system or component during or at the end of the development process to determine whether it meets the user’s or customer’s intended needs and requirements. In simple terms, validation answers the question, “Are we building the right product?” It is about ensuring that the product fulfills its intended use and is suitable for its intended purpose. Validation typically involves real-world usage and user acceptance testing.

In this instance, it is important to highlight that the *ESSENTIA CURRICULUM* is a set of interrelated elements that pursue a common goal. This makes the very definition of *ESSENTIA CURRICULUM* compatible with the definition of system, as shown in Figure 6-1, referring to a dictionary definition (Merriam-Webster, 2023). *ESSENTIA CURRICULUM* comprises a kernel, a language specification, a set of common practices, and a library of practices; these elements act together as the *ESSENTIA CURRICULUM* system.

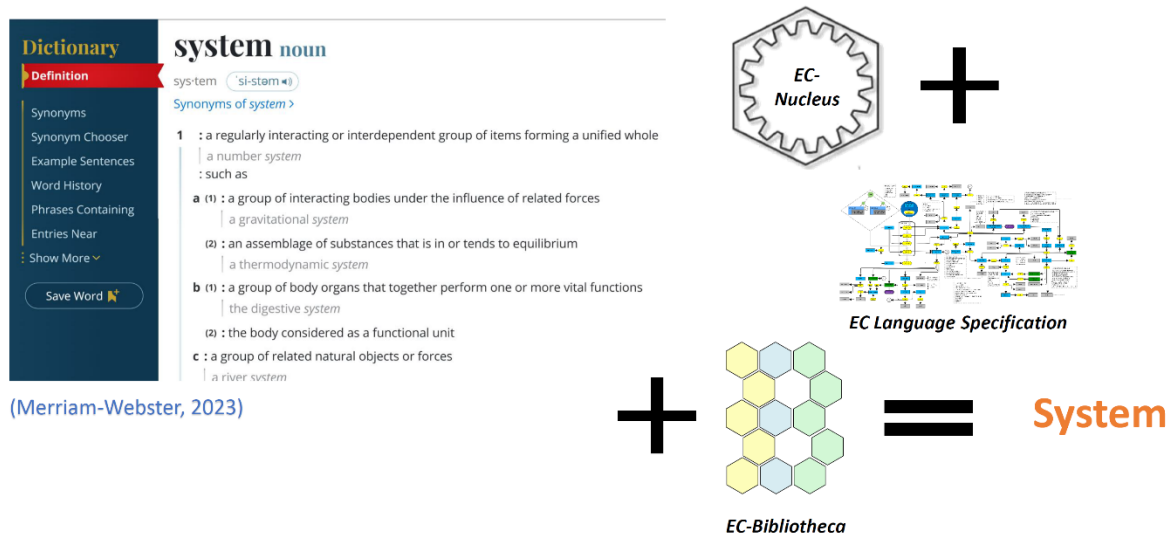


Figure 6-1: ESSENTIA CURRICULUM as a system.

Given that *ESSENTIA CURRICULUM* is identified as a system, it is appropriate to apply the IEEE 1012-2016 standard for its definition, as illustrated in Figure 6-2.

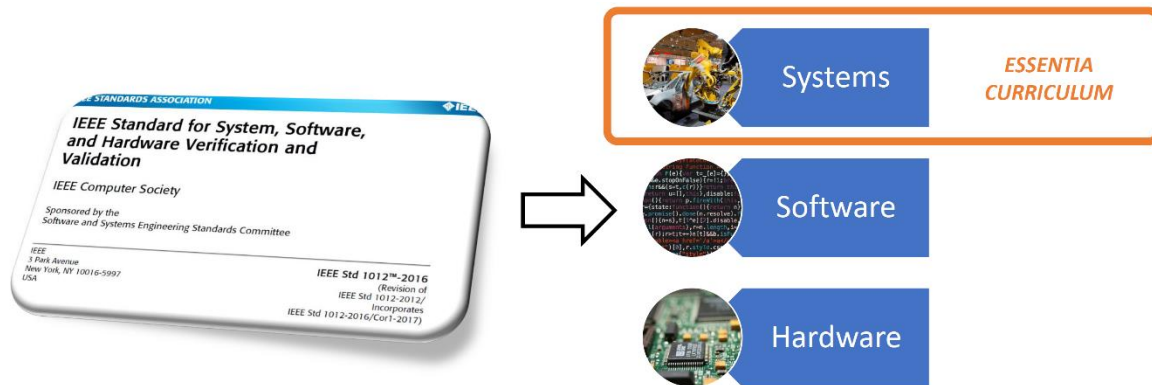


Figure 6-2: Applying the IEEE 1012-2016 standard for verification and validation.

In the IEEE 1012-2016 standard, various levels of integrity are established for system, software, and hardware verification and validation. These levels categorize the importance and impact of these components, influencing the rigor and extent of verification and validation processes (IEEE, 2016). The standard applies to new, existing, and reused systems, including all forms of software and hardware. This approach ensures that the V&V processes are appropriately aligned with the critical nature of the system or component being developed, maintained, or utilized.

The concept of integrity levels, as highlighted in the IEEE 1012-2016 standard, pertains to how a system’s impact is assessed within its context. This standard categorizes systems

into four integrity levels, ranging from high to low, based on the system’s perceived significance from the viewpoint of users (IEEE, 2016).

“The following key concepts are emphasized in this standard:

- Integrity levels. Defines four integrity levels to describe the importance of the system, software, and hardware, varying from high integrity to low integrity, to the user.”

(IEEE, 2016, p. 10)

Integrity Level	The behavior of the Curriculum Design causes the following:	Probability of occurrence
4	<ul style="list-style-type: none"> Catastrophic consequences Critical consequences 	<ul style="list-style-type: none"> At most occasional At most probable
3	<ul style="list-style-type: none"> Catastrophic consequences Critical consequences Marginal consequences 	<ul style="list-style-type: none"> At most infrequent At most occasional At most probable
2	<ul style="list-style-type: none"> Critical consequences Marginal consequences Negligible consequences 	<ul style="list-style-type: none"> At most infrequent At most probable At most reasonable
1	<ul style="list-style-type: none"> Critical consequences Marginal consequences Negligible consequences 	<ul style="list-style-type: none"> At most infrequent At most occasional at most probable

Figure 6-3: Integrity levels for V&V of *ESSENTIA CURRICULUM* based on Matthews (2023).

Figure 6-3 outlines four integrity levels in the context of system behavior outcomes and their probability of occurrence. This system behavior is related to applying *ESSENTIA CURRICULUM* in a curriculum design endeavor. Level 4 represents the highest integrity and is associated with catastrophic outcomes that could occur occasionally or probably. Level 3 pertains to consequences ranging from disastrous to marginal, varying likelihoods from infrequent to probable. Level 2 corresponds to critical to negligible significance outcomes, with occurrences ranging from infrequent to reasonable. Lastly, Level 1 indicates the lowest integrity level, with critical to negligible outcomes and a probability ranging from infrequent to probable.

Sentiment analysis is a computational technique for detecting and interpreting emotional responses in text data. It allows researchers to categorize opinions expressed in text, ranging from positive to negative sentiments. This method is particularly valuable for understanding consumer behavior and preferences in social science research, marketing, and customer service. For example, as noted by Liu (2012), sentiment analysis can effectively gauge public opinion on various topics from social media content.

Upon establishing the integrity levels for *ESSENTIA CURRICULUM*, the study revisited data from a global survey of 226 professors. Using NVivo software, the survey responses underwent sentiment analysis to identify four emotional categories in the professors’ descriptions of their curriculum design experiences and further comments. The sentiments ranged from highly positive to highly negative. The findings of this sentiment analysis are presented in Figure 6-4.

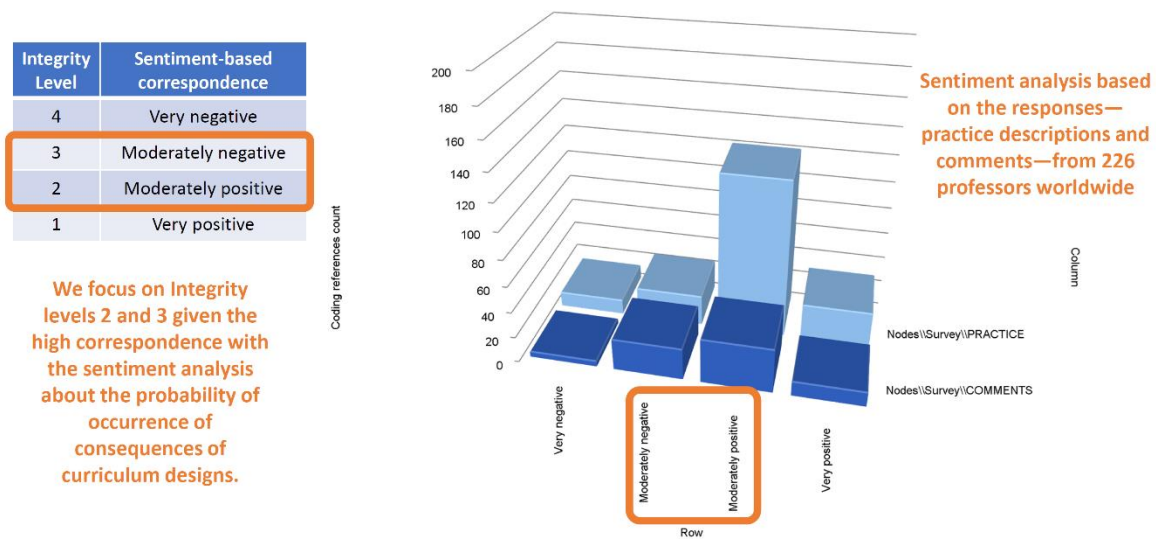


Figure 6-4: Results of the sentiment analysis and the correspondence with the integrity levels.

The most significant alignment between the sentiment analysis results and integrity levels defined in *ESSENTIA CURRICULUM* led to a concentrated emphasis on levels two and three, as outlined by the standard in Figure 6-5. This approach is strategically targeted at two key areas: ensuring that *ESSENTIA CURRICULUM* meets its specified requirements through a verification process and confirming its applicability and effectiveness in real-world settings via an acceptance testing procedure as a validation process.

“Testing is an activity that may be performed by various organizations within the development effort. This standard requires a minimum level of V&V testing dependent on the integrity level.”

(IEEE, 2016, p. 35)

System	V&V testing by integrity level			
	4	3	2	1
System Integration Testing V&V	Perform	Review	Review	No action
System Qualification Testing V&V	Perform	Review	Review	No action
System Acceptance Testing V&V	Perform	Review	Review	No action

Evaluating requirements engineering documentation

Evaluating acceptance in real scenarios

(IEEE, 2016, p. 36)

Figure 6-5: Two key areas for verification and validation, respectively.

6.1 Verification process on *ESSENTIA CURRICULUM*

Following the IEEE 1012-2016 standard, the verification process applied to *ESSENTIA CURRICULUM* is focused on the requirements validation, as depicted in Figure 6-6.

8.3 Activity: System Requirements Definition V&V (System, 15288—System Requirements Definition process)		
V&V tasks	Required inputs	Required outputs
<p>(1) Requirements Evaluation Evaluate the system requirements for correctness, consistency, completeness, readability, and testability. The task criteria are as follows:</p> <p>a) Correctness</p> <p>1) Verify and validate that the required characteristics, attributes, constraints (e.g., mechanical, electrical, mass, thermal, data, procedural flows), and functional and performance requirements for a product solution are correct (e.g., security, ergonomics, human-machine interface, safety, reliability, maintainability, response time).</p>	<p>Stakeholders requirements</p> <p>System requirements</p> <p>Concept documentation</p> <p>Organizational processes and procedures</p>	<p>Task report(s)—Requirements evaluation</p> <p>Anomaly report(s)</p>

Figure 6-6: Excerpt of the system requirements definition V&V according to IEEE (2016, p. 65).

Requirements engineering documentation is a critical aspect of software development and serves as the foundation for creating effective and functional systems. According to Sommerville (2016), this documentation involves systematically collecting and specifying software requirements and ensuring that they are precise, clear, and comprehensive. This process guides the development team and provides a reference point for future maintenance and updates.

In examining the requirements engineering documentation, this research leveraged contributions from undergraduate students enrolled in the Requirements Engineering course at the Universidad Nacional de Colombia at Medellín during the latter half of 2022. Guided by our supervision, these students of the Systems Engineering Program compiled a document detailing the engineering requirements, which encompasses 19 curriculum design practices represented in Quintessence, 66 elicitation cards, 3 goal diagrams, 37 executable pre-conceptual schemas, 3 domain models, 56 use cases, 3 cause-effect diagrams, 3 process diagrams, and 3 event interaction graphs. These components of the requirements engineering documentation are depicted in Figure 6-7.

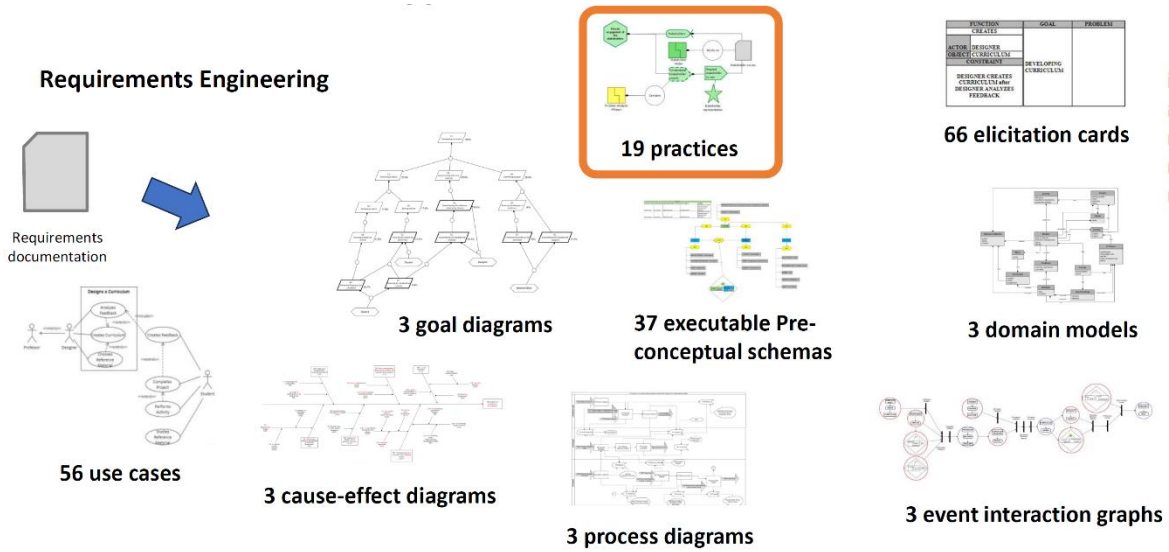


Figure 6-7: Components of the requirements engineering documentation.

The standard was applied to evaluate curriculum design practices previously represented in Quintessence by the students through the lens of *ESSENTIA CURRICULUM*, ensuring strict adherence to the kernel and language specification of *ESSENTIA CURRICULUM*. This process confirmed *ESSENTIA CURRICULUM*'s capability to fulfill the documented requirements. For illustrative purposes, Figure 6-8 exemplifies *ESSENTIA CURRICULUM*'s re-interpretation of a curriculum design practice from the requirements engineering document. All 19 practices were re-interpreted in the same way as depicted in the Annex B.

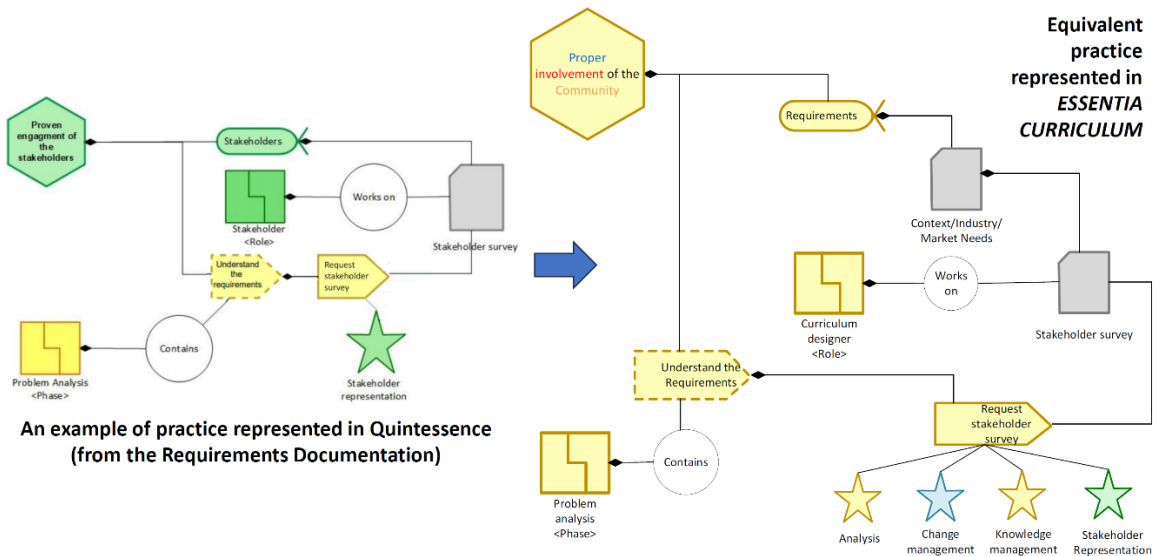


Figure 6-8: An example of re-interpretation of a practice by using *ESSENTIA CURRICULUM*.

6.2 Validation process on *ESSENTIA CURRICULUM*

After completing the requirements verification, the next phase involves evaluating the real-world efficacy of *ESSENTIA CURRICULUM* in depicting curriculum design practices. This is conducted by the standard, which advises validation in actual environments, specifically at integrity levels 2 and 3. An example of this adherence is illustrated in Figure 6-9, which highlights a segment that aligns with standard guidelines (IEEE, 2016).

V&V tasks	Required inputs	Required outputs
<p>(7) <u>System Acceptance Test Plan V&V</u></p> <p>a) System integrity level 4</p> <p>1) Plan V&V system acceptance testing to validate that the system correctly implements system requirements in the intended operational environment or as close to the intended operational environment as possible. The resulting V&V system acceptance test plan shall address the following:</p>	<p>System requirements</p> <p>Stakeholders requirements</p> <p>System acceptance test plan (acquirer's)</p>	<p>V&V system acceptance test plan (integrity level 4)</p> <p>Task report(s)— Review of system acceptance test plan (integrity levels 3 and 2)</p>

Figure 6-9: Excerpt of the system acceptance test plan V&V according to IEEE (2016, p. 68).

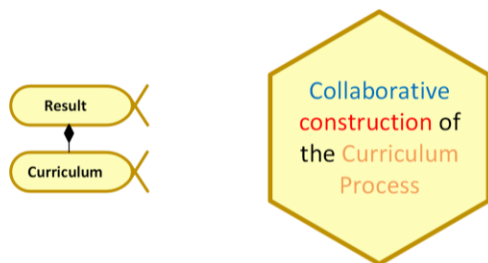
“Curriculum Processes” is part of a textbook by Góyes and Uscátegui (2000) that has guided curriculum design for over two decades at the University of Nariño. It is essential to highlight that the University of Nariño, which currently holds a high-quality institutional accreditation, has 11 faculties, 107 academic programs with qualified registration, and 35 academic programs with high-quality accreditation. All accredited programs at the University of Nariño have followed the guidelines of the textbook, which describe how to design a curriculum for the local context. The “Curriculum Processes” is thus considered an excellent reference and an authority on curriculum design with proven results.

Considering the terminological unification developed in the early steps in constructing *ESSENTIA CURRICULUM*, all practices represented in this approach must be well-named and well-formed, as proposed by Barón (2019). Every practice represented in *ESSENTIA CURRICULUM* must be named with an adjective, a nominalized verb, and a noun from the unified glossary. In the validation stage, a practice called the “collaborative construction of the curriculum process” is proposed in this regard. Colored words have a special meaning based on the *ESSENTIA CURRICULUM* rules. This practice encompasses all the aspects of the textbook that have been an institutional reference for the curriculum designs of the high-quality accredited academic programs of the University of Nariño.

The Ph.D. Program in Educational Sciences at the University of Nariño has a tradition of more than two decades of training doctors in pedagogy, didactics, curriculum, and evaluation, among others. This program is part of a national research network called RUDECOLOMBIA, which integrates 12 public universities nationwide. This network currently boasts high-quality institutional accreditation granted by the National Accreditation Council, an organization attached to the Ministry of National Education.

In 2023, 10 students from the Ph.D. program enrolled in the “Hermeneutics and Computational Linguistics” course, where the validation of *ESSENTIA CURRICULUM* was developed based on the institutional textbook. Consequently, the “Hermeneutics and Computational Linguistics” course included a representation of the practice called “collaborative construction of the curriculum process” from the Curriculum Processes textbook based on *ESSENTIA CURRICULUM* in its content. Some elements were initially identified in the text and reinterpreted. Figure 6-10 depicts the basis for representing a practice of the “Curriculum Processes” textbook proposed by Góyes and Uscátegui (2000).

Curriculum Processes



Adjective: Collaborative
 Nominalized Verb: Construction (from “to construct”)
 Noun: Curriculum Process

Source: Ph.D. students, Hermeneutics & Computational Linguistics course, Sep-2023, Ph.D. Program of Education Sciences, University of Nariño

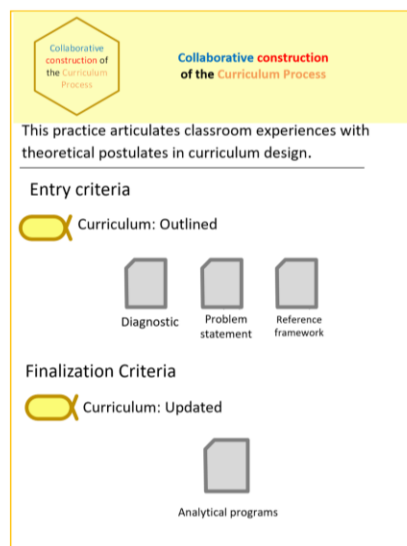


Figure 6-10: Bases representing a practice from the “Curriculum processes” textbook.

During the validation segment, Ph.D. students in educational sciences received guidance on utilizing the kernel and the language specification of *ESSENTIA CURRICULUM* within their course, using some examples. This instruction enabled them to translate theoretical concepts from their textbooks into representations using *ESSENTIA CURRICULUM*. Consequently, the students could summarize the “collaborative construction of the

curriculum process” practice. Figure 6-11 depicts an excerpt of the previous work done by the Ph.D. students in the process of interpreting the textbook to represent its theoretical concepts in *ESSENTIA CURRICULUM*.

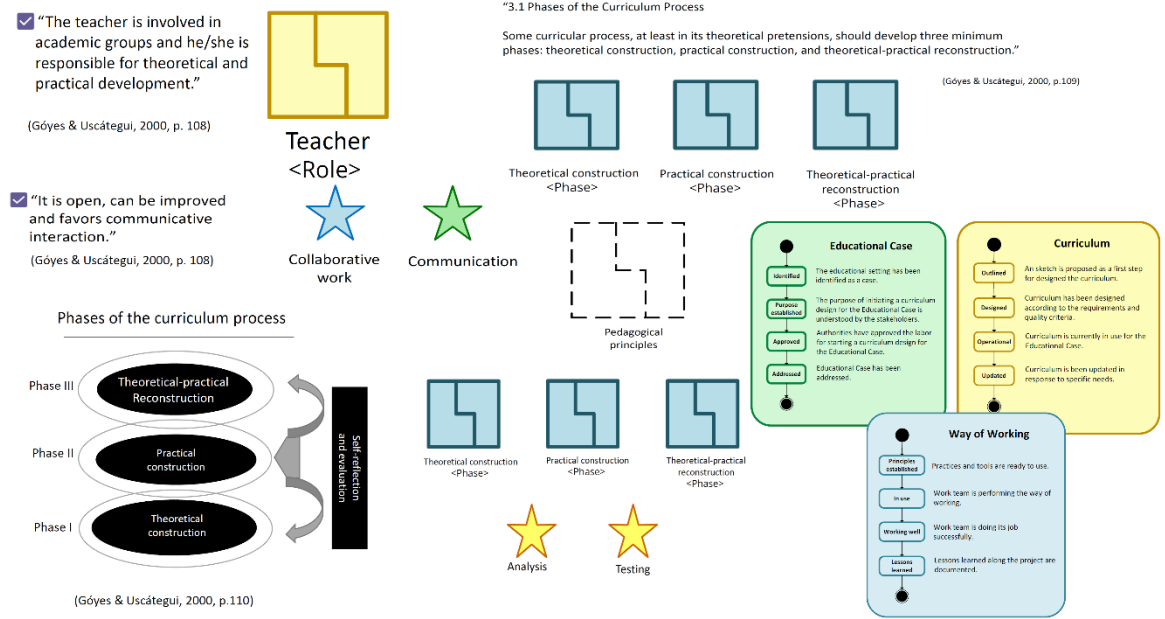


Figure 6-11: Excerpt of the early works on interpreting theoretical constructs.

Through a collaborative effort, the Ph.D. students assembled a full depiction of the “collaborative construction of the curriculum process” practice by crafting a pair of coordinated illustrations shown in Figures 6-12 and 6-13. The initial illustration highlights the application of ALPHAs and their corresponding work products, while the latter delineates the sequence of activities pertinent to the practice. It is worth emphasizing that the representation of this practice within *ESSENTIA CURRICULUM* captures all the theorized concepts presented in the textbook when the practice was proposed.

To confirm the comprehensiveness of the practice representation in *ESSENTIA CURRICULUM*, the Ph.D. students revisited the textbook section on “Curriculum Processes.” During this review, they were able to correlate the elements of the *ESSENTIA CURRICULUM* representation with the textbook content. This exercise concluded that the *ESSENTIA CURRICULUM* practice indeed encompasses all the theoretical concepts outlined in the original textbook.

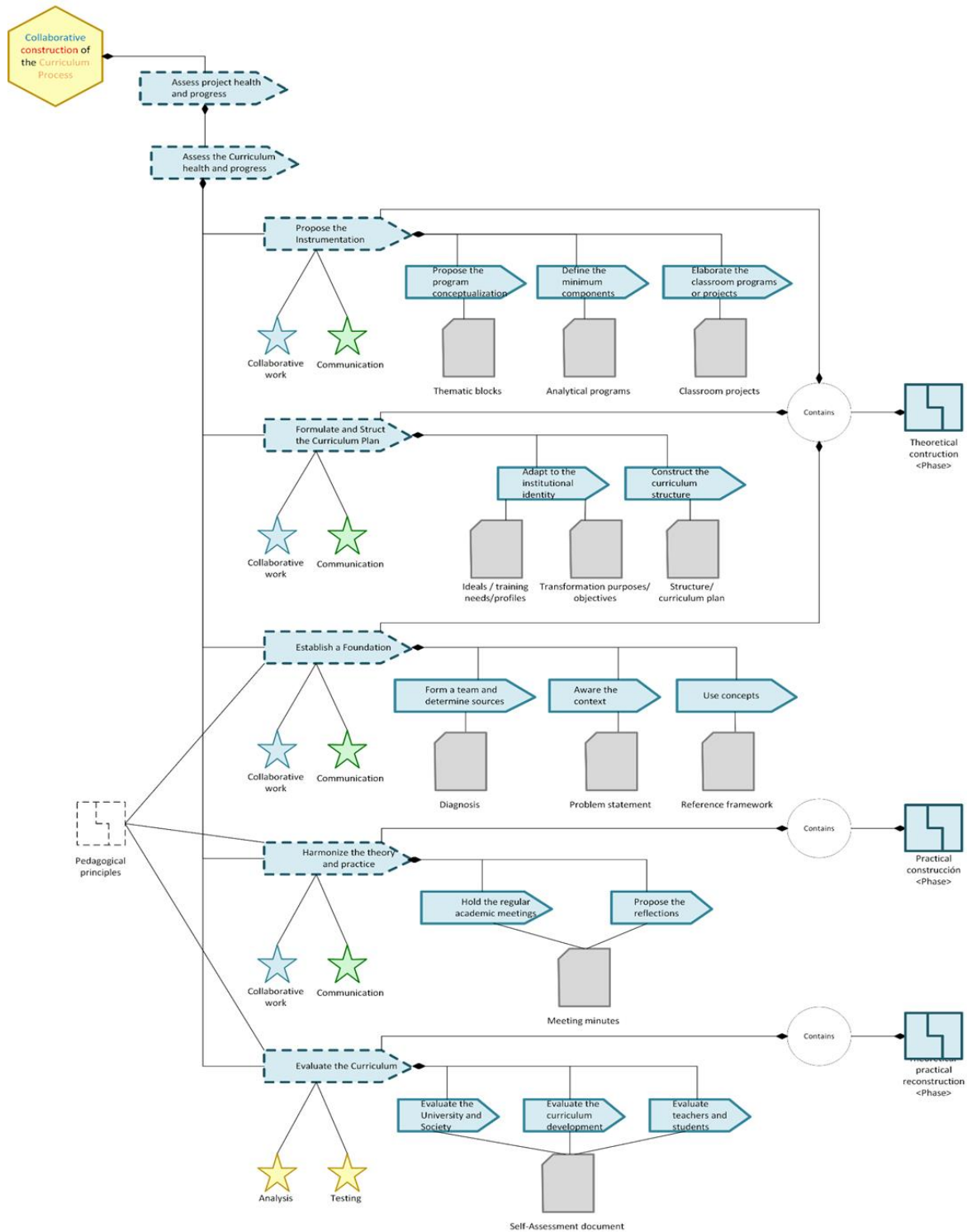


Figure 6-12: “Collaborative construction of the curriculum processes” practice represented in *ESSENTIA CURRICULUM*, part 1.

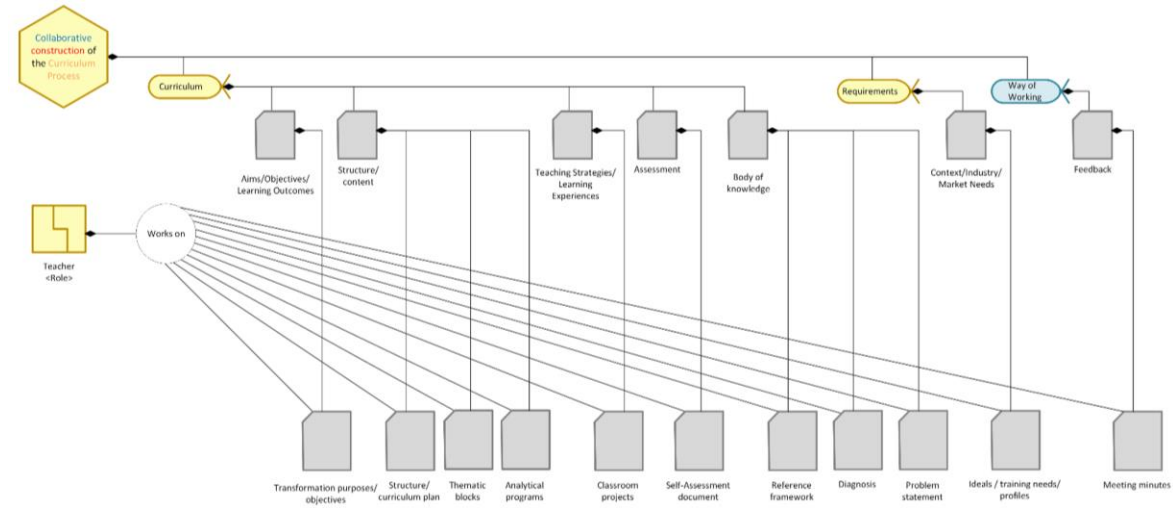


Figure 6-13: “Collaborative construction of the curriculum processes” practice represented in *ESSENTIA CURRICULUM*, part 2.

To enhance their experience with *ESSENTIA CURRICULUM* in an academic context, 10 Ph.D. students participated in a survey that included both quantitative and qualitative questions. The outcomes of this survey are presented in Figures 6-14 to 6-17.

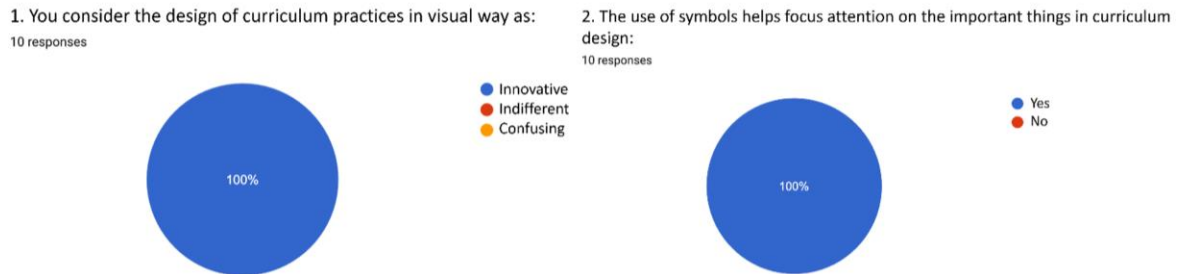


Figure 6-14: Validating the visual approach and symbology on experiencing *ESSENTIA CURRICULUM*.

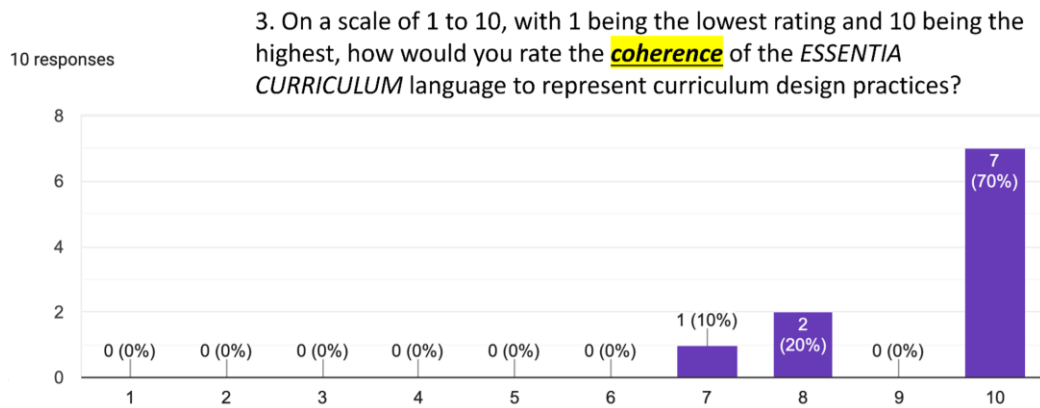


Figure 6-15: Validating the coherence on experiencing *ESSENTIA CURRICULUM*.

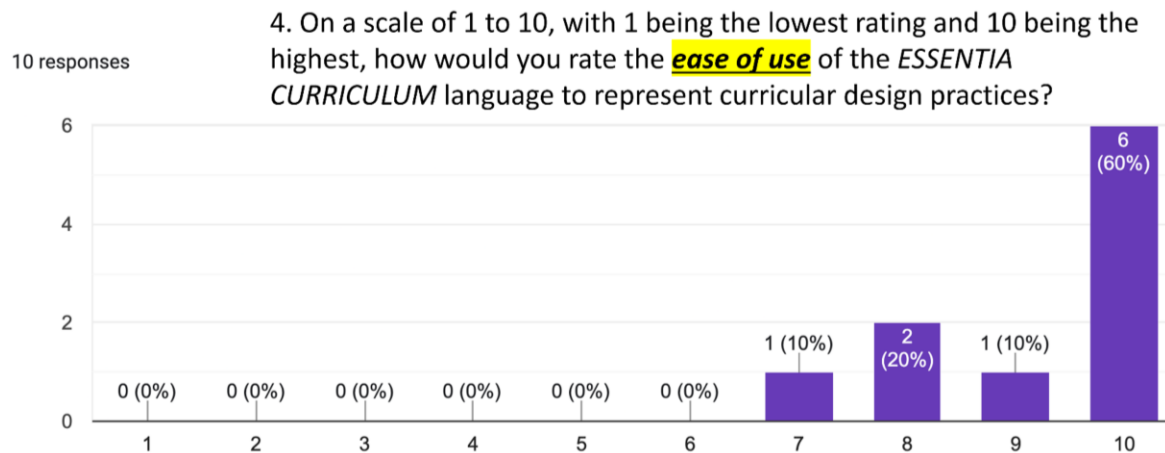


Figure 6-16: Validating the ease of use on experiencing *ESSENTIA CURRICULUM*.

5. Please write a **final comment** about your experience with *ESSENTIA CURRICULUM* when representing curriculum design practices:

"A new way of generating curricular innovation where dynamism and relevance are combined to contextualize the teaching and learning processes, and in turn generate tools of great help for the continuous improvement of curriculum processes in educational settings... Allows greater understanding of each of the steps in curriculum design... I find it innovative and relevant to the world we live in. Excellent... I congratulate the initiative developed and I hope to learn more about it in detail... I believe that all tools contribute to the development of the academy and are products that should be considered for use and analysis. Excellent development... It is necessary to put the software into practice in different contexts of curricular design... I appreciate the willingness of Doctor Jesús to guide the seminar. A didactic, flexible and accessible strategy. I think this project is excellent... I congratulate Professor Jesús, excellent course. Thanks professor!... After having observed the handling by Doctor Jesús Insuasti it was motivating since the use of graphics and diagrams facilitate the understanding of the language, we are waiting for the next step regarding the development of the software that is based on such a language and already exports the product works (i.e. syllabus) from the designed curriculum. Good luck... Very practical and wonderful, without a doubt the practical way to obtain a design using a flexible algorithm. Congratulations!"

Ideas for future work

Figure 6-17: Final comments on experiencing *ESSENTIA CURRICULUM*.

The benefits of such collaborative activities extend beyond the academic outcomes of any single project, fostering a sense of community and shared purpose among students while encouraging the exchange of ideas, promoting critical thinking, and enabling them to appreciate the value of diverse viewpoints. All these features were achieved using *ESSENTIA CURRICULUM*. Through collective problem-solving and negotiation, students develop communication and consensus-building skills that are vital for academic and professional success. Additionally, the group construction of knowledge, facilitated by activities such as the *ESSENTIA CURRICULUM* workshop, exemplifies the social constructivist paradigm, in which learning is seen as a socially situated activity and knowledge is built through interaction with others.

Finally, incorporating collaborative strategies in curriculum design enhances the learning experience and mirrors real-world scenarios that require interdisciplinary teamwork and

cooperation. This approach, as demonstrated in the Ph.D. program in which students are experiencing *ESSENTIA CURRICULUM*, leads to developing a more robust and versatile curriculum representation and equips students with the interpersonal and communication skills necessary for leadership in educational innovation.

6.3 Demonstrating the prevalence of the common practices in *ESSENTIA CURRICULUM*

In computational linguistics, semantic equivalence analysis is a critical process that serves several foundational purposes. Understanding and ensuring semantic equivalence is essential when developing systems that interpret, generate, or translate human language. Semantic equivalence in computational linguistics refers to situations in which different linguistic expressions convey the same meaning, and it is a way of validating expressions. (Frawley, 1984). This concept is vital in fields such as machine translation, where the goal is to retain the original meaning across languages. Semantic equivalence also plays a role in NLP tasks, such as paraphrasing and text summarization. The challenge in achieving semantic equivalence lies in understanding the context and cultural nuances that influence meaning.

Considering the relevant role of semantic equivalence in computational linguistics, we moved forward with developing PCS-AI v1.0, a web application supported by NLP. After retraining the BERT model and fine-tuning the Llama 2-Chat model, the technical specifications for its construction and deployment included Ubuntu Server 22.04, Unicorn Flask, GoJS API, and Python 3.10. This web-based platform utilizes NLP to process basic pre-conceptual schemas through these models in our initial attempt to automate the interpretation of pre-conceptual schemas. “Pre-conceptual schemas are a straightforward way to represent knowledge using controlled language regardless of context. Despite the benefits of using pre-conceptual schemas by humans, they present challenges when interpreted by computers” (Insuasti *et al.*, 2023, p. 1). Thus, we created and used a web application called PCS-AI v1.0 to perform semantic equivalences between the texts involved in the curriculum design representation in *ESSENTIA CURRICULUM*.

ESSENTIA CURRICULUM emerges from computational linguistics analysis of a linguistic corpus specialized in curriculum design. It incorporates a century’s worth of theoretical knowledge, 14 documented experiences, and insights from a survey of 226 professors

worldwide and emphasizes 10 common practices as a foundational theory for any representation of curriculum design practice, regardless of context. Thus, this Ph.D. Thesis focuses on these common practices as standard benchmarks, highlighting reinterpretations based on semantic equivalence techniques applied in the validation exercise, as shown in Figure 6-18.

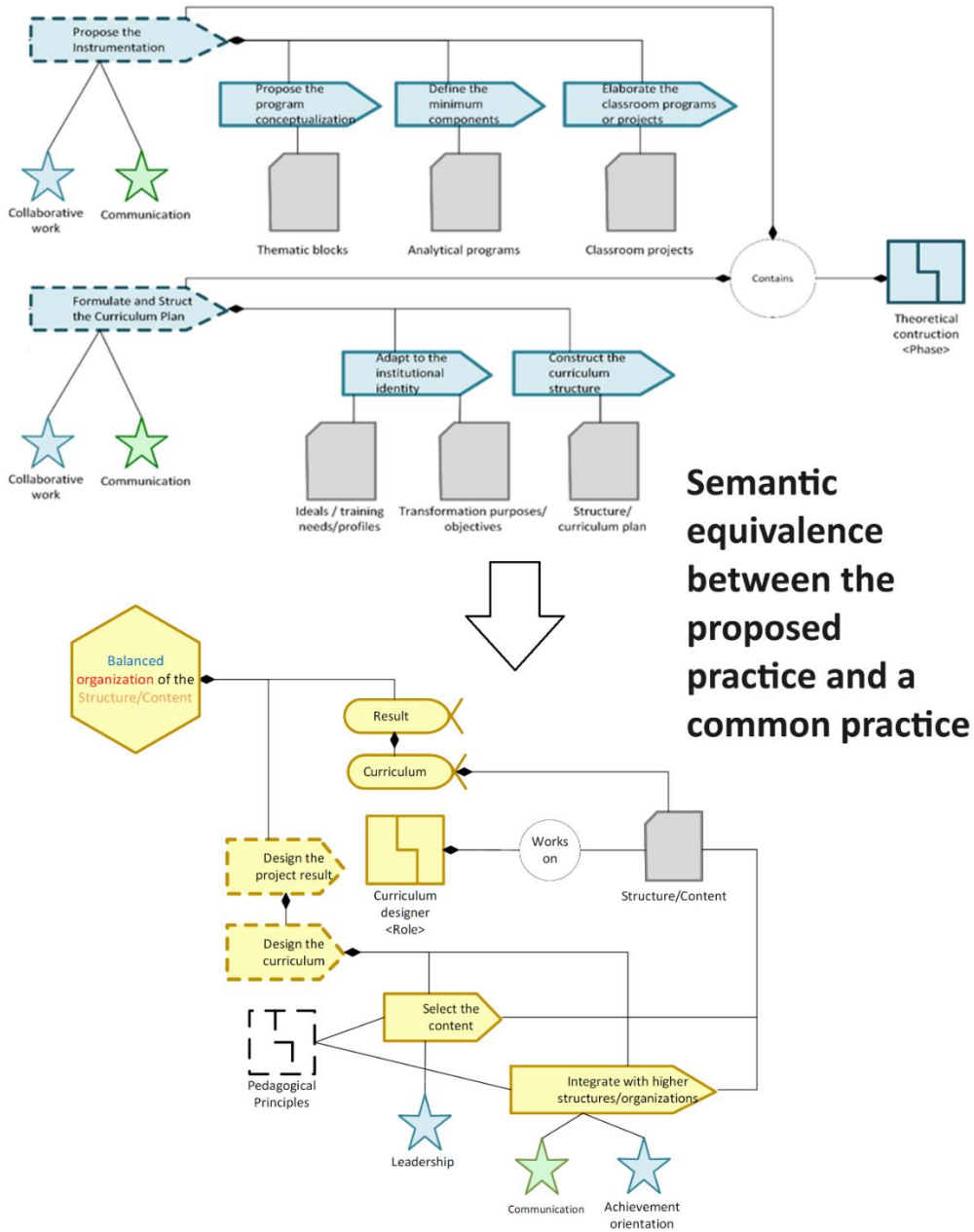


Figure 6-18: Excerpt of the semantic equivalence between the proposed practice and a common practice.

For instance, the Ph.D. students used some phrases they employed in their representations, and their phrases were consistent with the theoretical concepts derived from the textbook. In analyzing semantic equivalence through artificial intelligence using our computational tool, as depicted in Figure 6-19, we observed that they achieved significant percentages, suggesting that the practice proposed by the students is highly related to prevalent common practices. Thus, the proposed practice can be re-interpreted using the common practices implicit in *ESSENTIA CURRICULUM*.

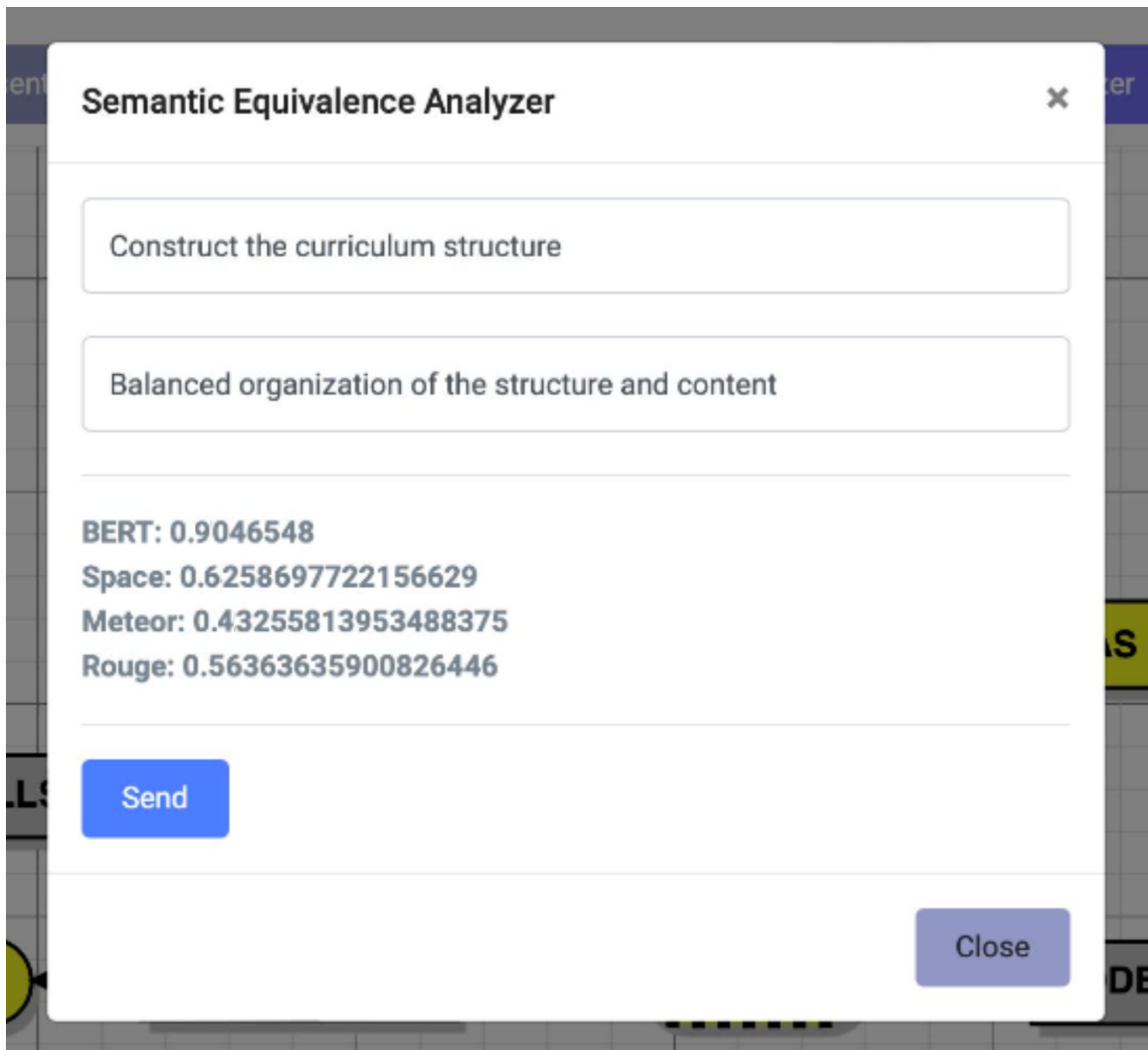


Figure 6-19: A sample of semantic equivalent analysis by using PCS-AI v1.0.

We derived these percentages indicating semantic equivalence by utilizing our computational tool on the phrases students chose about the names of our common

practices within *ESSENTIA CURRICULUM*. Table 6-1 displays the percentages resulting from the semantic equivalent analysis.

We have incorporated the BERT and LLama2 models into version 1.0 of our computational tool for their intended use. Recently, we have incorporated three large language models (LLM), in addition to both initial models. It is crucial to clarify that the Spacy, Rouge, Meteor, and BERT models are used in the training and fine-tuning of linguistic models and are specifically focused on the domain of curriculum design, enhancing the effectiveness of the semantic equivalence analyzer. Consequently, the phrase input into our computational tool was already presumed by the linguistic models to be within the realm of curriculum design, guided by the datasets from our linguistic corpus.

Table 6-1: The semantic equivalence analysis results using PCS-AI v1.0.

Proposed Phrases vs. <i>ESSENTIA CURRICULUM</i> common practice	BERT LLM	Space LLM	Meteor LLM	Rouge LLM
Propose the instrumentation versus balanced organization of the structure and content	0.8167701	0.65040422	0.34705882	0.399999996
Propose the program conceptualization versus balanced organization of the structure and content	0.8641004	0.67118166	0.31627907	0.381818177
Defining the minimum components versus balanced organization of the structure and content	0.778995	0.57108046	0.31627907	0.381818177
Elaborate the classroom programs or projects versus balanced organization of the structure and content	0.8356426	0.84206712	0.28196721	0.353846149
Formulate and struct the curriculum plan versus balanced organization of the structure and content	0.84173937	0.75472704	0.36393443	0.507692303
Adapt to the institutional identity versus balanced organization of the structure and content	0.91823335	0.74570181	0.29615385	0.366666662
Construct the curriculum structure versus balanced organization of the structure and content	0.9046548	0.62586977	0.43255814	0.563636359
LLM average:	0.85144795	0.69443316	0.33631866	0.422211118
General average	0.57610272			

Consequently, after applying the four LLMs and calculating the average results for each, we obtained 57% in semantic equivalence as a general average, which surpasses the mean. According to our criteria, surpassing the mean (50%) in the general average of the semantic equivalence analysis for each LLM warrants an acceptable evaluation. By contrast, the equivalence is deemed unacceptable if this threshold is unmet.

Using this approach, we extended the analysis to include the remaining phrases utilized by the Ph.D. students. We also identified semantic equivalences with the 10 common practices in *ESSENTIA CURRICULUM*. Table 6-2 and Figure 6-20 show the semantic equivalence of the practice proposed by the Ph.D. students. In summary, the method that defines the “collaborative construction of the curriculum processes” practice is semantically equivalent to the method composed of the common practices of “balanced organization of the structure and content,” “accurate analysis of the needs,” and “learned feedback from the curriculum design,” as indicated by the acceptability assessment in the linguistic analysis. This shows that the 10 common practices in *ESSENTIA CURRICULUM* sufficiently represent any effort in curriculum design.

Table 6-2: Semantic equivalence of the proposed practice with the *ESSENTIA CURRICULUM* common practices.

#	<i>ESSENTIA CURRICULUM</i> common practices	Semantic equivalence applied to the “collaborative construction of the curriculum processes” practice
1	Detailed finding of the participants	0.393862932
2	Specific consideration of the knowledge/interests of students	0.217642183
3	Educational application ok knowledge	0.429003497
4	Accurate analysis of the needs	0.551028725
5	Proper definition of aims/objectives/learning outcomes	0.483109661
6	Balanced organization of the structure/content	0.576102718
7	Academic proposition on teaching strategies/learning experiences	0.287610887
8	Structured establishment of the assessment	0.370912743
9	Sufficient support of materials	0.218721607
10	Learned feedback from the curriculum design	0.569821731

Semantic equivalence of the "Collaborative construction of the Curriculum Processes" practice with the ESSENTIA CURRICULUM common practices

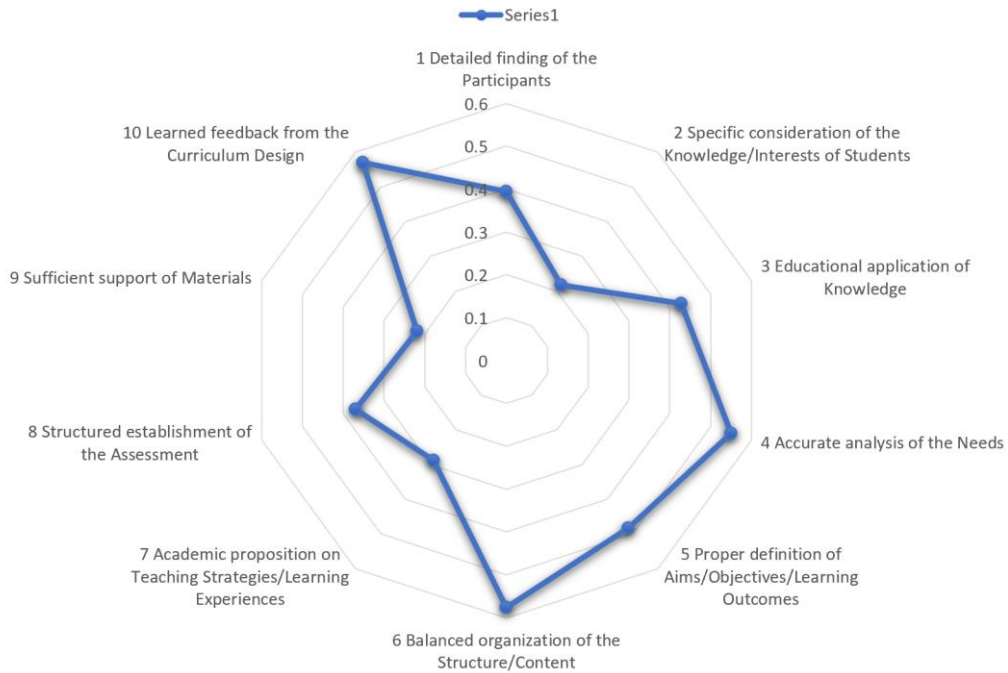


Figure 6-20: Radial representation of the semantic equivalence of the proposed practice with the ESSENTIA CURRICULUM common practices.

As a general conclusion in this activity, we have that the method that contains the “collaborative construction of the curriculum processes” practice is semantically equivalent to the method that includes the ESSENTIA CURRICULUM common practices: “balanced organization of the structure and content,” “accurate analysis of the needs,” and “learned feedback from the curriculum design,” as shown in Figure 6-21.

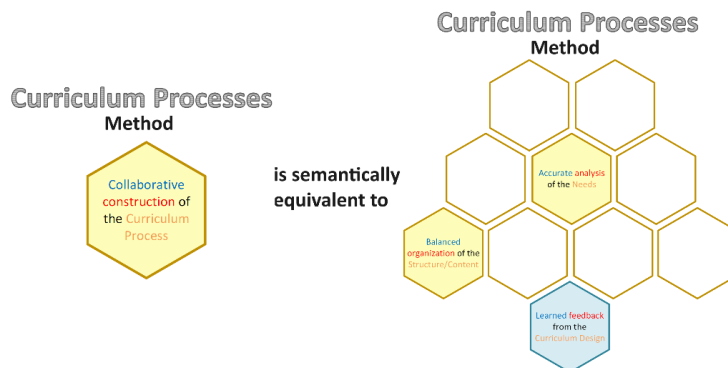


Figure 6-21: “Curriculum Processes” method represented in ESSENTIA CURRICULUM.

In this vein, we can generate semantically equivalent methods from *ESSENTIA CURRICULUM* common practices of any method. Table 6-3 depicts the semantic equivalence percentages applied to the 22 classical methods from a century of curriculum design theory to show how such methods are represented by *ESSENTIA CURRICULUM*.

Table 6-3: Semantic equivalence applied to methods from a century of curriculum design theory.

Method Authors	1. Detailed finding of the Participants	2. Specific consideration of the Knowledge/Interests of Students	3. Educational application of Knowledge	4. Accurate analysis of the Needs	5. Proper definition of Aims/Objectives /Learning Outcomes	6. Balanced organization of the Structure/Content	7. Academic proposition on Teaching Strategies/Learning Experiences	8. Structured establishment of the Assessment	9. Sufficient support of Materials	10. Learned feedback from the Curriculum Design
Kilpatrick (1918)	0.534781	0.540447	0.534108	0.513422	0.506112	0.507982	0.540692	0.557804	0.481439	0.495027
Bobbitt (1924)	0.545338	0.498714	0.511423	0.575271	0.580887	0.502393	0.493106	0.490450	0.559489	0.477008
Charters (1929)	0.532740	0.542041	0.513775	0.523742	0.517723	0.509841	0.514309	0.530457	0.480571	0.530520
Rugg (1930)	0.537069	0.565231	0.527849	0.525028	0.573496	0.494759	0.490872	0.528362	0.508863	0.563250
Caswell and Campbell (1935)	0.484508	0.549165	0.482420	0.525456	0.526015	0.521423	0.565224	0.553488	0.511903	0.516487
Tyler (1949)	0.501560	0.545286	0.510119	0.552189	0.525597	0.520497	0.539284	0.533834	0.550613	0.542899
Smith, Stanley, and Shores (1957)	0.509736	0.476368	0.547452	0.481497	0.524823	0.492179	0.499989	0.556456	0.559925	0.567039
Taba (1962)	0.511594	0.546347	0.543443	0.515376	0.489651	0.576445	0.574453	0.548216	0.545416	0.489724
Kerr (1968)	0.521103	0.539011	0.530929	0.540280	0.494052	0.547821	0.505633	0.530898	0.478186	0.544768
Nicholls and Nicholls (1972)	0.543141	0.501364	0.545194	0.510894	0.510017	0.550861	0.555422	0.533458	0.559897	0.553744
Stenhouse (1975)	0.489513	0.554294	0.531267	0.547204	0.495068	0.531388	0.541928	0.550132	0.528912	0.558032
Bruner (1977)	0.519312	0.570941	0.520906	0.513284	0.527506	0.565152	0.523851	0.555495	0.490092	0.518026
Walters (1978)	0.514477	0.511217	0.566978	0.514374	0.486869	0.549347	0.542923	0.542703	0.492961	0.522567
Grayson (1979)	0.513001	0.529482	0.490658	0.555771	0.547929	0.550732	0.506603	0.531301	0.492159	0.559695
Perkins (1998)	0.499504	0.503644	0.510139	0.488899	0.490486	0.563783	0.486887	0.561750	0.525255	0.568618
Wiggins and McTighe (1999)	0.475889	0.477088	0.517973	0.506118	0.520516	0.527421	0.569261	0.540311	0.485700	0.490938
Isman et al. (2005)	0.517269	0.516144	0.544605	0.508850	0.523367	0.528058	0.524578	0.547089	0.544142	0.517288
van den Akker et al. (2006)	0.489665	0.561230	0.490485	0.520035	0.534930	0.559235	0.504428	0.533480	0.548164	0.553412
Clarke et al. (2015)	0.486001	0.531526	0.524013	0.497789	0.527426	0.499818	0.540781	0.508700	0.555962	0.485728
Young and Perovic (2016)	0.552107	0.480083	0.491135	0.523184	0.525604	0.487167	0.517003	0.491337	0.479853	0.540303
IBE-UNESCO (2017)	0.558978	0.514429	0.550211	0.521414	0.492378	0.484915	0.523997	0.546153	0.505436	0.503503
Ornstein and Hunkins (2018)	0.540621	0.559440	0.557861	0.518156	0.534436	0.553735	0.508446	0.544180	0.489386	0.565290

These findings clearly suggest that all designers are free to use *ESSENTIA CURRICULUM* to create their curriculum designs. Beyond the designers' freedom of use, the common practices of *ESSENTIA CURRICULUM* may be reused to represent any curriculum design regardless of the context or its nature. Figures 6-22 to 6-43 depict *ESSENTIA CURRICULUM*'s representation of the methods from a century of curriculum design theory.

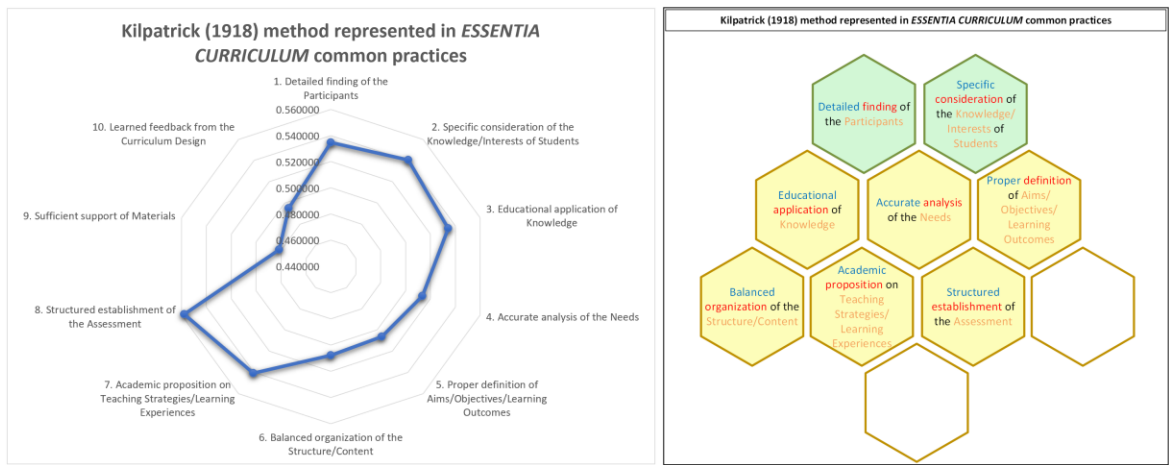


Figure 6-22: Kilpatrick's method (1918) represented in *ESSENTIA CURRICULUM*.

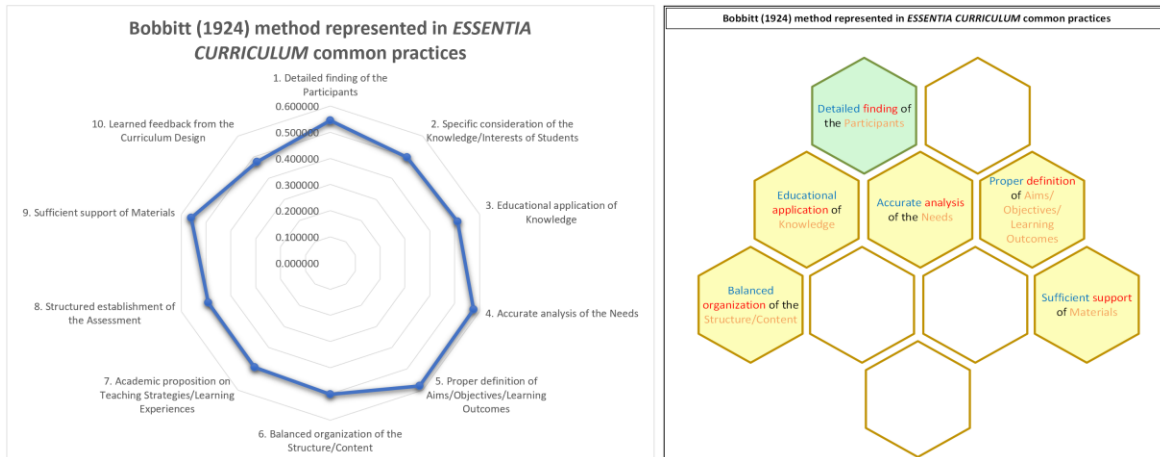


Figure 6-23: Bobbitt’s method (1924) represented in ESSENTIA CURRICULUM.

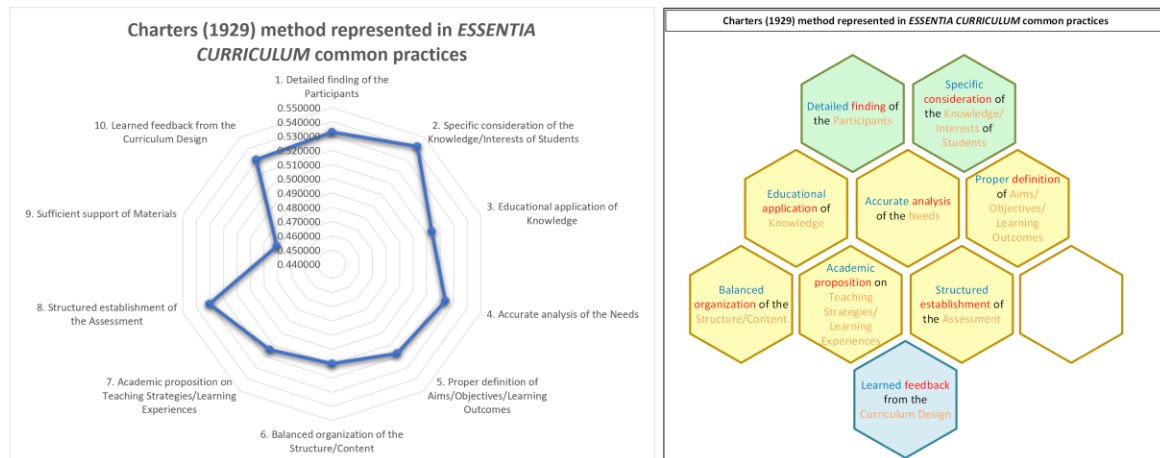


Figure 6-24: Charters’ method (1929) represented in ESSENTIA CURRICULUM.

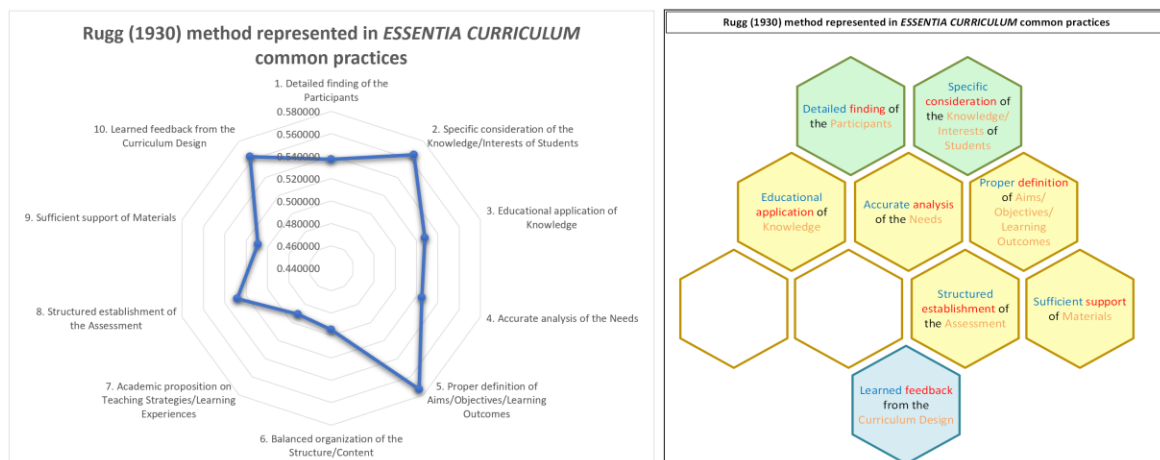


Figure 6-25: Rugg’s method (1930) represented in ESSENTIA CURRICULUM.

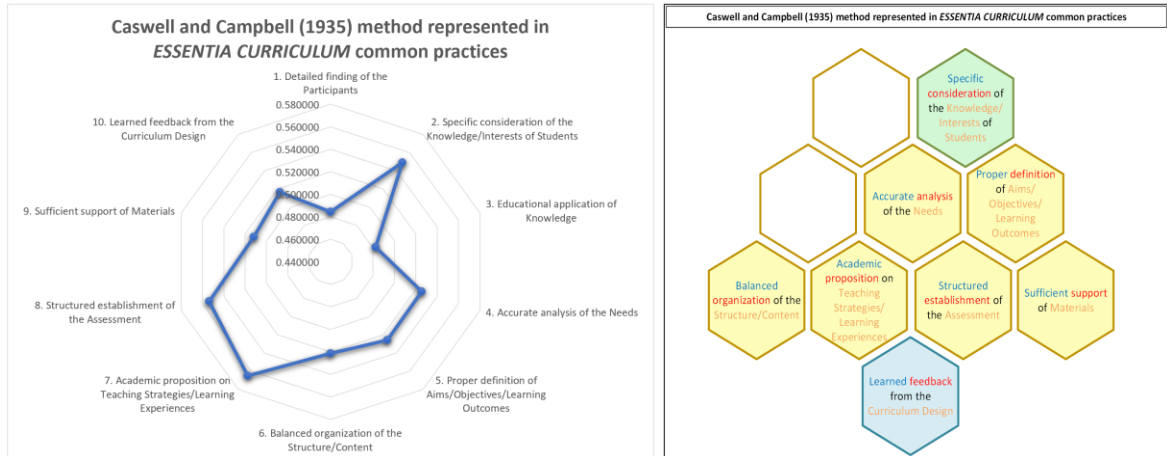


Figure 6-26: Caswell and Campbell’s method (1935) represented in *ESSENTIA CURRICULUM*.

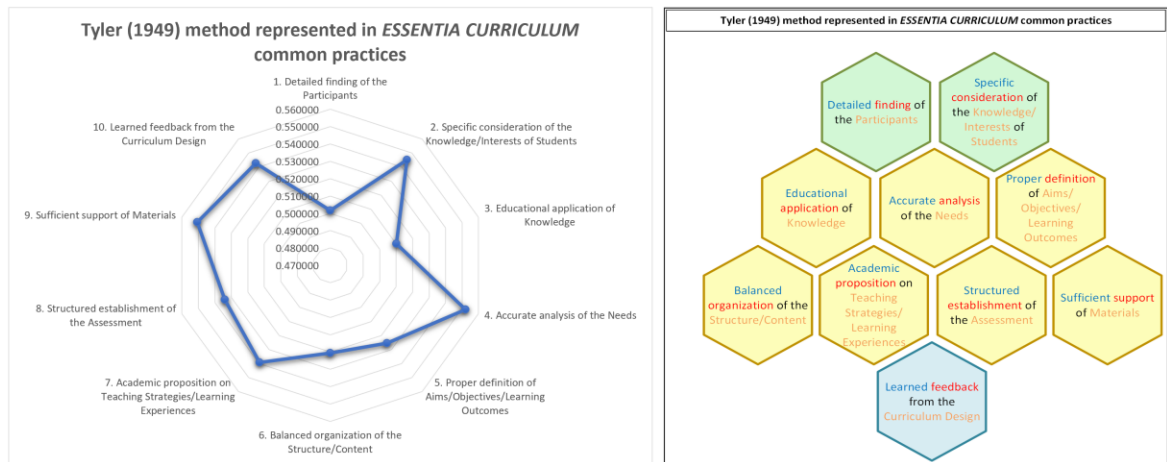


Figure 6-27: Tyler’s method (1949) represented in *ESSENTIA CURRICULUM*.

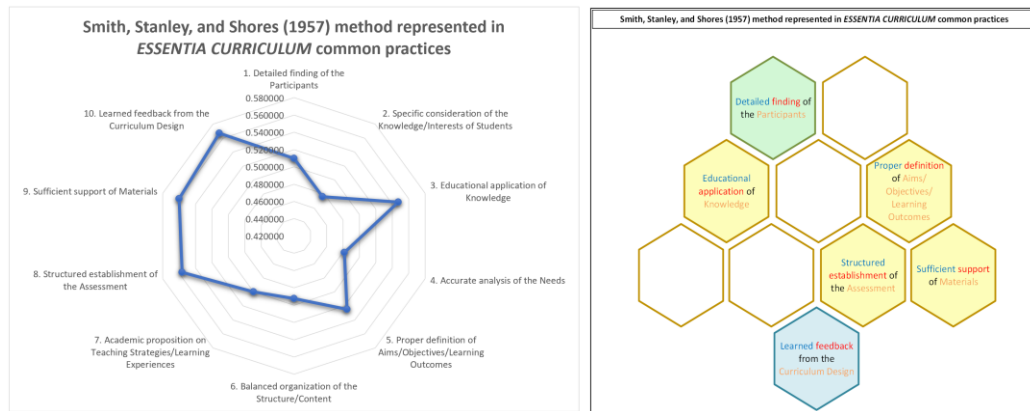


Figure 6-28: Smith, Stanley, and Shores’ method (1957) represented in *ESSENTIA CURRICULUM*.

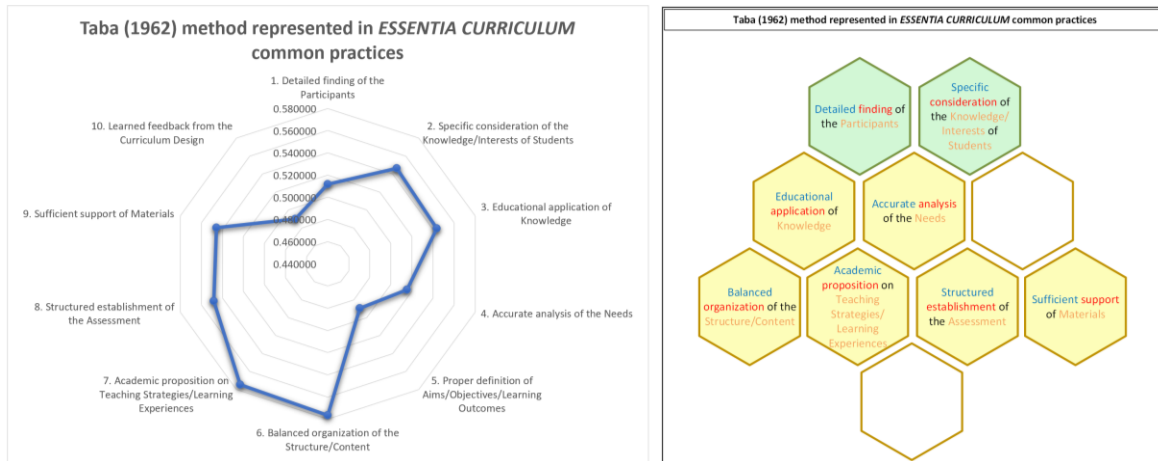


Figure 6-29: Taba’s method (1962) represented in *ESSENTIA CURRICULUM*.

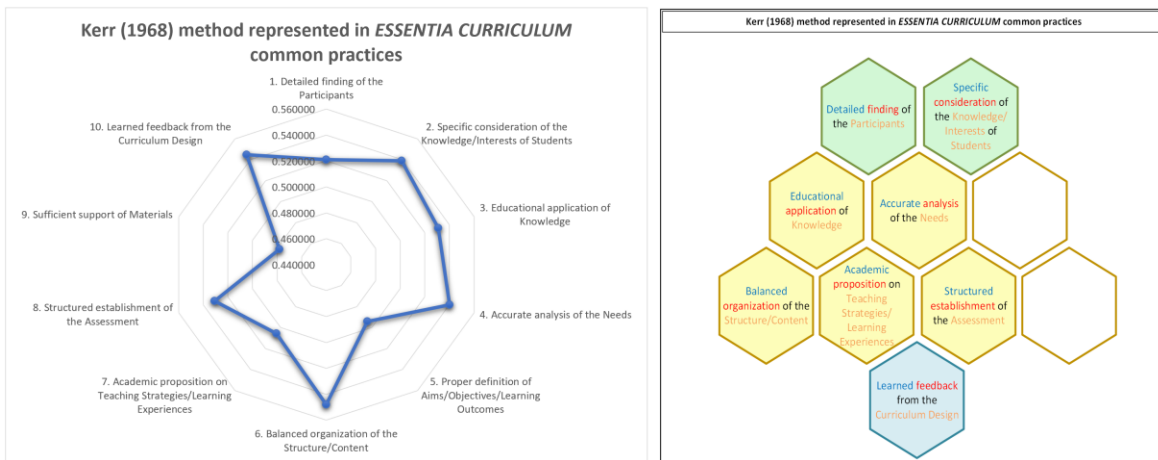


Figure 6-30: Kerr’s method (1968) represented in *ESSENTIA CURRICULUM*.

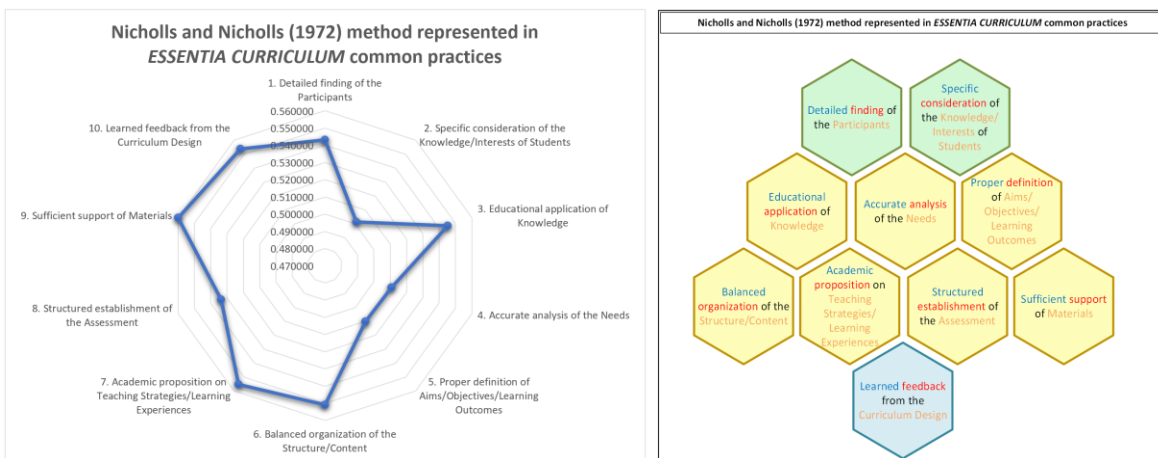


Figure 6-31: Nicholls and Nicholls’ method (1972) represented in *ESSENTIA CURRICULUM*.

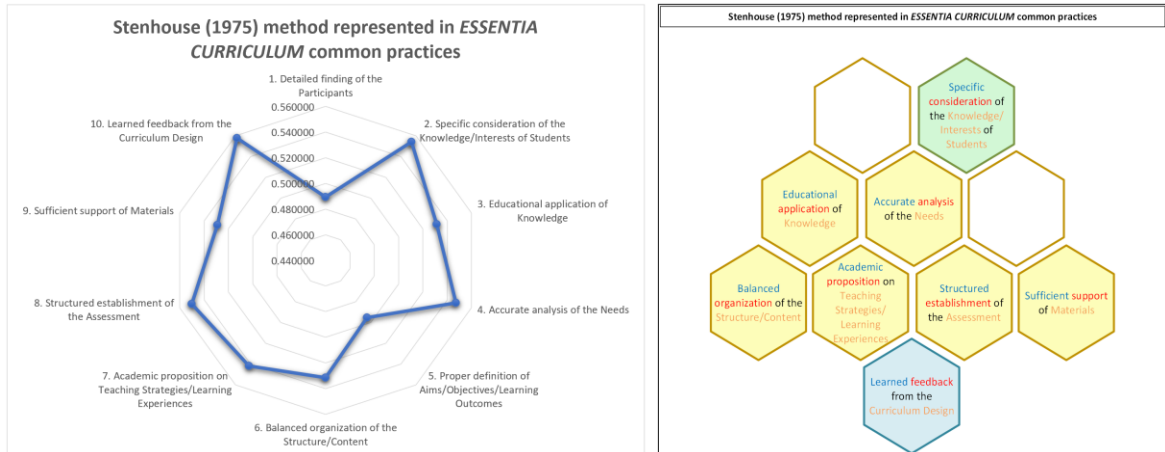


Figure 6-32: Stenhouse’s method (1975) represented in *ESSENTIA CURRICULUM*.

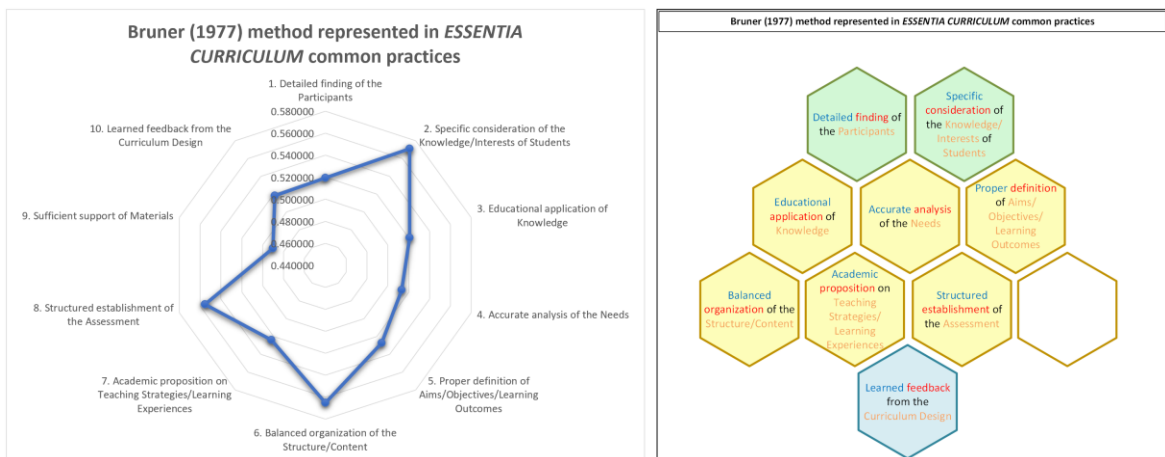


Figure 6-33: Bruner’s method (1977) represented in *ESSENTIA CURRICULUM*.

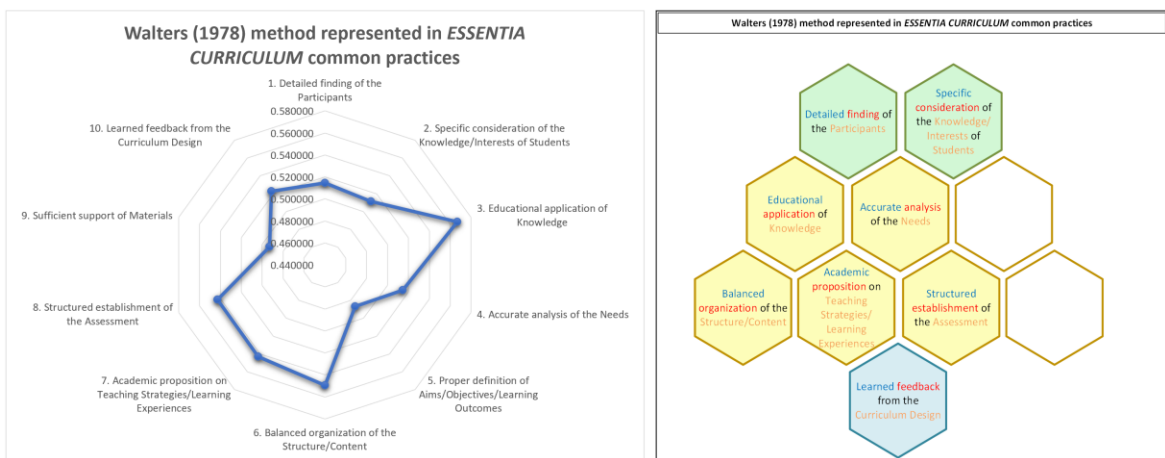


Figure 6-34: Walters’ method (1978) represented in *ESSENTIA CURRICULUM*.

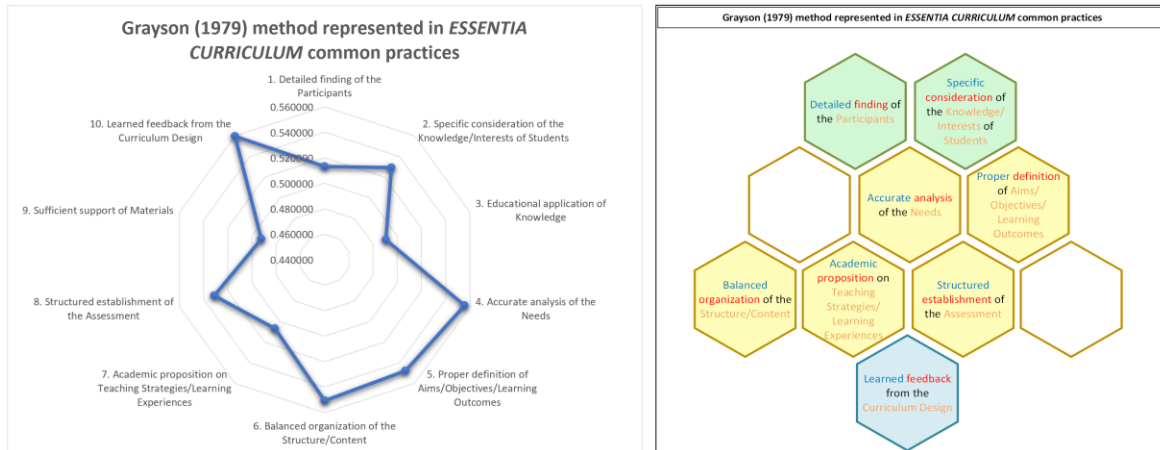


Figure 6-35: Grayson’s method (1979) represented in ESSENTIA CURRICULUM.

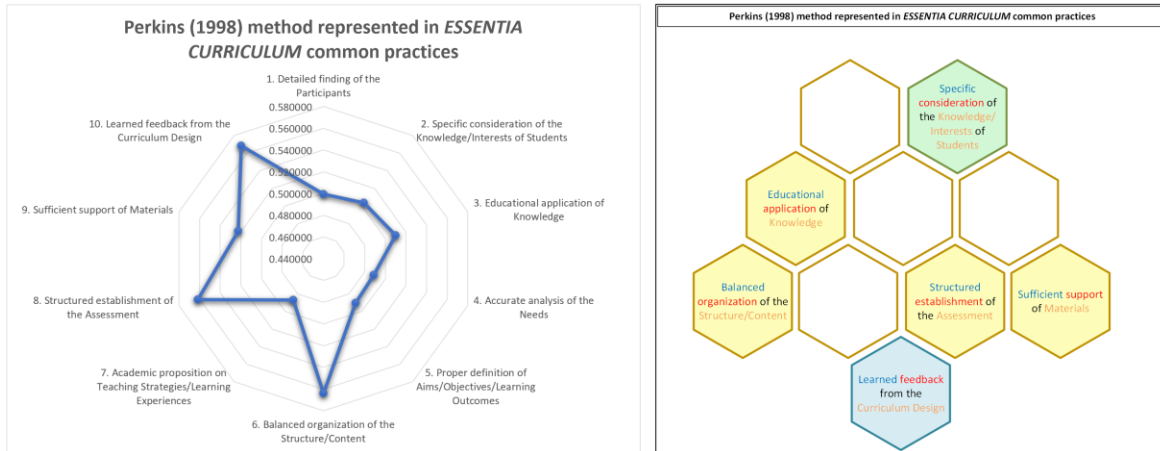


Figure 6-36: Perkins’ method (1998) represented in ESSENTIA CURRICULUM.

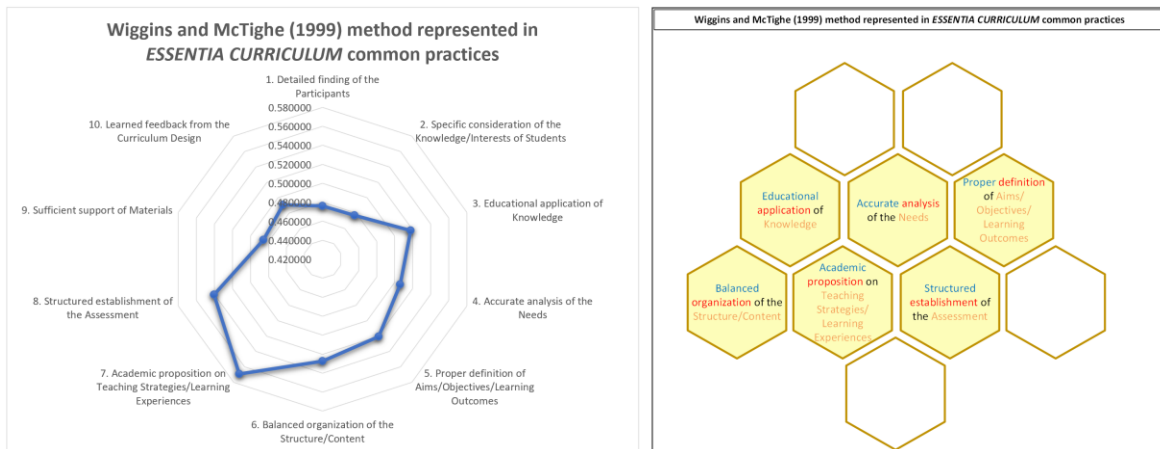


Figure 6-37: Wiggins and McTighe’s method (1999) represented in ESSENTIA CURRICULUM.

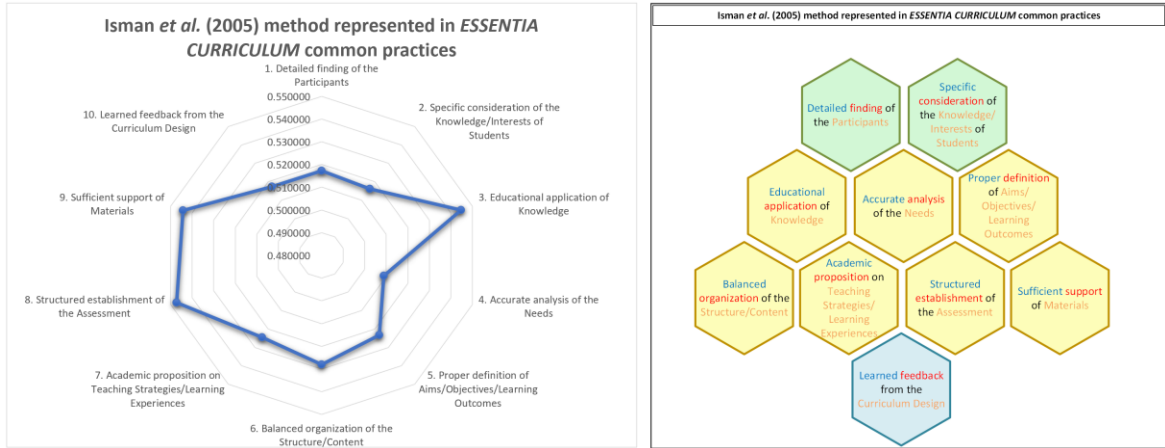


Figure 6-38: Isman et al.'s method (2005) represented in ESSENTIA CURRICULUM.

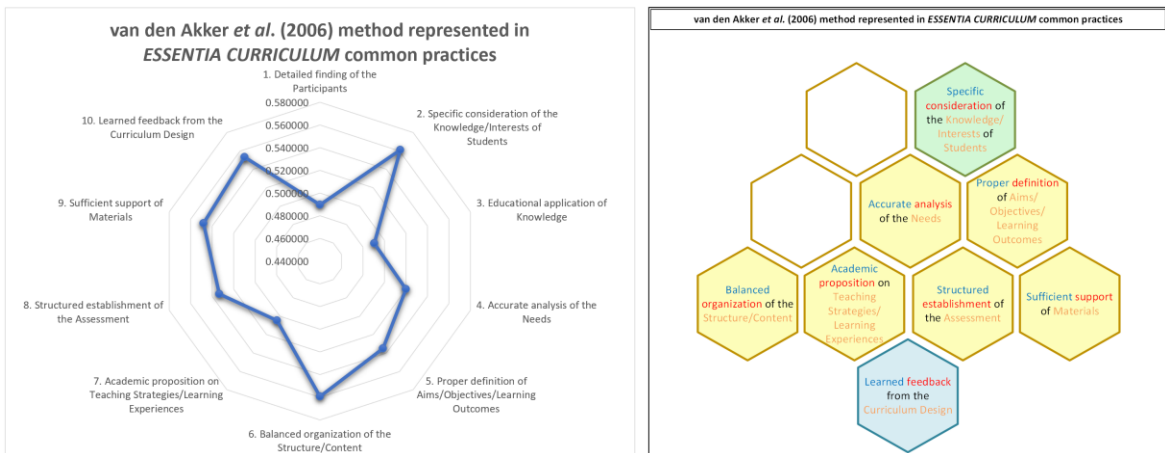


Figure 6-39: van den Akker et al.'s method (2006) represented in ESSENTIA CURRICULUM.

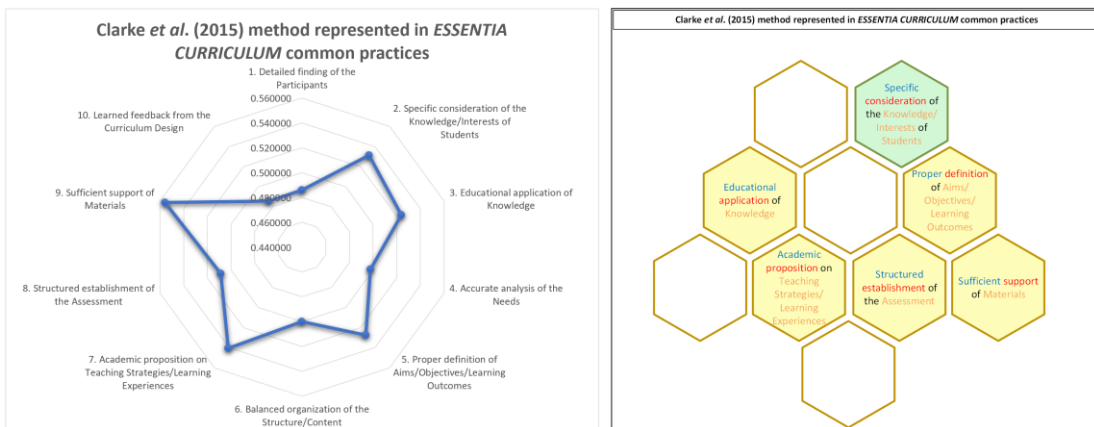


Figure 6-40: Clarke et al.'s method (2015) represented in ESSENTIA CURRICULUM.

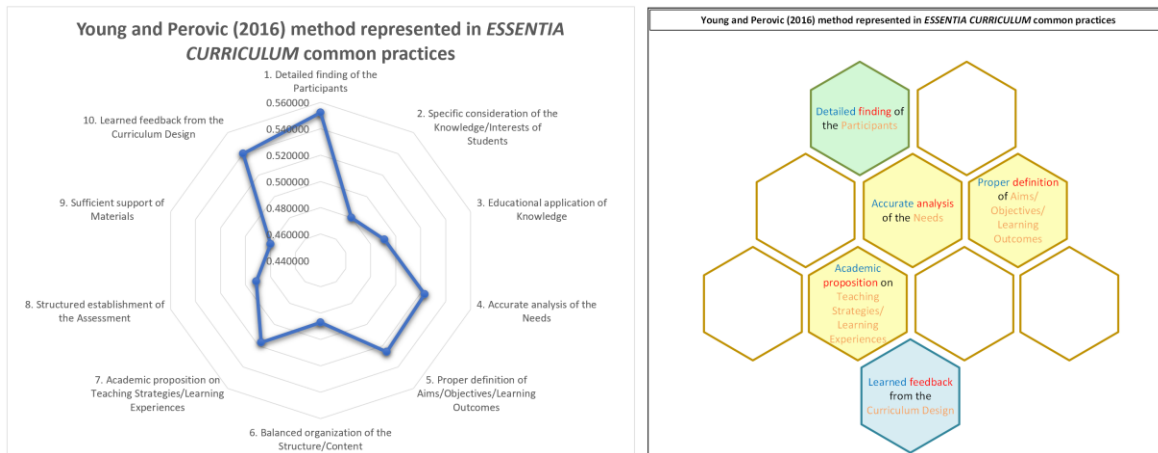


Figure 6-41: Young and Perovic’s method (2016) represented in ESSENTIA CURRICULUM.

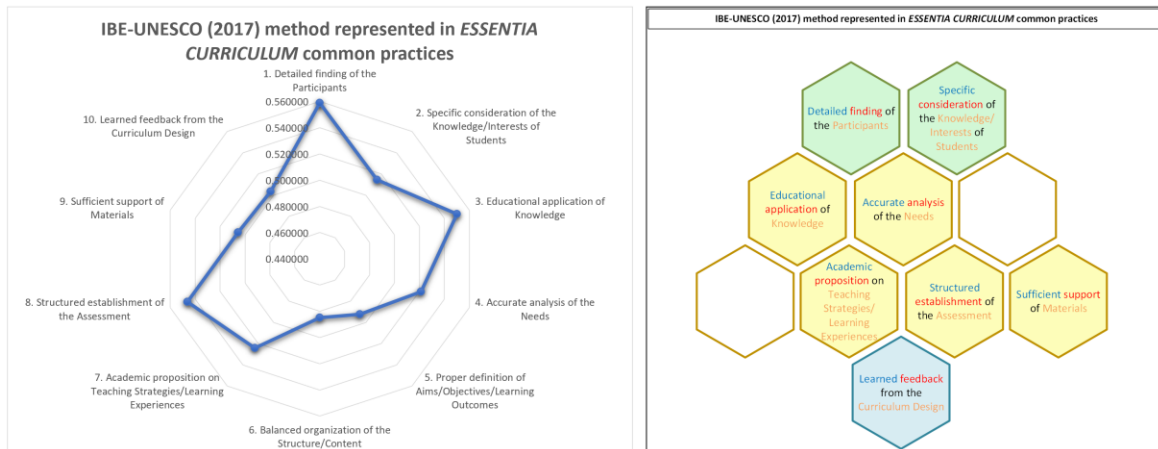


Figure 6-42: IBE-UNESCO’s method (2017) represented in ESSENTIA CURRICULUM.

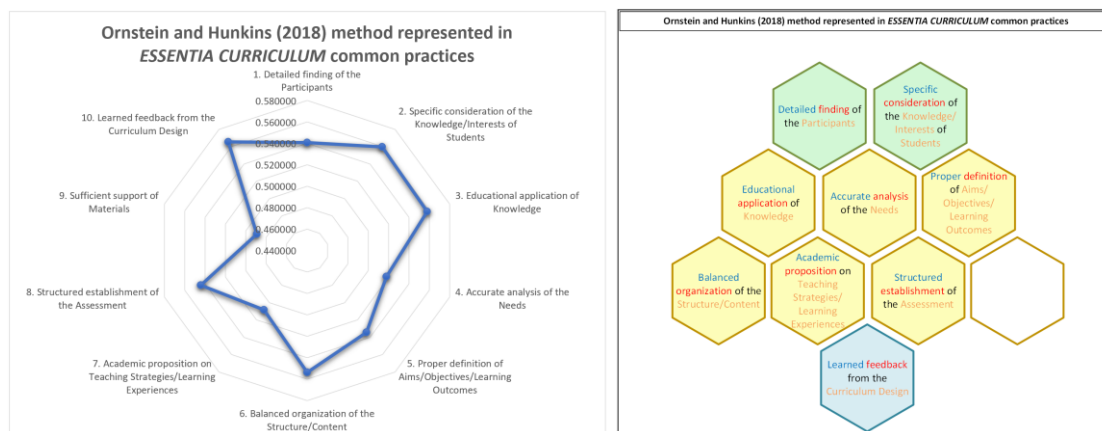


Figure 6-43: Ornstein and Hunkins’ method (2018) represented in ESSENTIA CURRICULUM

7. Conclusions, contributions, and future work

7.1 Conclusions

This Ph.D. Thesis highlights a significant gap between theoretical curriculum design methods and practices, as identified in a century's worth of literature, and the empirical practices observed globally. This disparity results in diverse working methods and various graphical representations in curriculum design. However, there is a notable lack of comprehensive documentation and reliable, observable verification of such practices from an engineering perspective. Addressing this issue, we developed *ESSENTIA CURRICULUM*, grounded initially in a theoretical framework tailored for computing-related academic programs and based on the software engineering principles of the SEMAT Essence kernel. Our approach began with constructing a linguistic corpus from the literature, 14 documented experiences, and 226 professors with expertise in curriculum design. This process involved eliciting common practices, unifying terminology, and adapting the SEMAT Essence kernel to create *EC-Nucleus*. This nucleus forms the foundation of *ESSENTIA CURRICULUM*, offering a clear, context-free language specification that extends beyond computing-related disciplines.

Through computational linguistics analysis of this corpus, we successfully identified common practices, leading to the creation of the *ESSENTIA CURRICULUM* method, which comprises 10 common practices. These common practices and various curriculum design representations contributed by the community have been compiled into EC-Bibliotheca, an expanding online repository. The effectiveness of *ESSENTIA CURRICULUM* was validated in an academic setting, yielding positive results in line with the IEEE 1012-2016 standard. This research bridges the gap between theory and practice in curriculum design. It provides a robust, adaptable framework that can be applied across various academic fields beyond computing-related educational environments. In this vein, *ESSENTIA CURRICULUM*

simultaneously constitutes four elements: a system, a theory, a method, and a model, as depicted in Figure 7-1.



Figure 7-1: *ESSENTIA CURRICULUM* at a glance.

ESSENTIA CURRICULUM as a system: *ESSENTIA CURRICULUM* is a set of interrelated elements that support curriculum design endeavors.

ESSENTIA CURRICULUM as a theory: *ESSENTIA CURRICULUM* is a well-substantiated explanation of curriculum design aspects based on evidence and logical reasoning. *ESSENTIA CURRICULUM* was born from a linguistic corpus processed by computational linguistics techniques.

ESSENTIA CURRICULUM as a method: *ESSENTIA CURRICULUM* is a systematic way of designing a curriculum involving a specific procedure according to its kernel and language specification.

ESSENTIA CURRICULUM as a model: *ESSENTIA CURRICULUM* is a simplified representation of the reality related to curriculum design affairs to face their complexity and heterogeneity. *ESSENTIA CURRICULUM* is also highly adaptable and replicable to different scenarios. Its kernel and its language specification form the model of *ESSENTIA CURRICULUM*.

By following the structure of the research of this Ph.D. Thesis, we present the conclusions for each specific objective:

1. Identifying Common Practices

We have successfully identified common practices from diverse global experiences in curriculum design within computing-related programs and beyond. In this regard, we create a linguistic corpus from 22 methods in curriculum design theory of a century, 14 documented experiences in curriculum design, and the responses of 226 professors worldwide. This initiative has enabled us to extract and distill key methods and practices

used across continents, creating a comprehensive corpus that reflects the shared knowledge and unique challenges of curriculum design in the education sector. Our linguistic corpus synthesizes both theoretical and practical viewpoints regarding curriculum design endeavors. This achievement marks a significant step forward in understanding and enhancing educational frameworks.

2. Unifying Terminology

Through meticulous analysis and collaboration, we have unified the terminology derived from the varied experiences we studied, establishing a common theoretical foundation for curriculum design. This harmonization of language and concepts not only facilitates clearer communication among professionals but also strengthens the academic rigor of curriculum design studies. This unified terminology serves as the bedrock upon which further scholarly and practical work can build.

3. Proposing Modifications to the SEMAT Essence Kernel

We proposed relevant modifications to the Semat Essence kernel by incorporating elements specific to curriculum design in computing-related programs and beyond, referred to as the *EC-Nucleus*. This tailored version of the SEMAT Essence framework addresses the unique aspects of computing education and enhances the kernel's applicability and effectiveness in academic settings, paving the way for more targeted and impactful curriculum development.

4. Building a Library of Practices (*EC-Bibliotheca*)

The establishment of the *EC-Bibliotheca*, a library of practices specifically curated for curriculum design, has been a significant achievement. Utilizing the *EC-Nucleus* as its core, this library serves as a vital resource for educators, practitioners, and curriculum designers, offering accessible, and systematically categorized practices that are grounded in both theory and real-world application.

5. Verifying and validating the *EC-Nucleus* and *EC-Bibliotheca*

We have rigorously verified and validated both the *EC-Nucleus* and the *EC-Bibliotheca* in accordance with the IEEE 1012:2016 standard. This process ensured that our methods and results meet high-quality assurance benchmarks, providing a reliable and robust foundation for future curriculum activities. In addition, semantic equivalence processes were performed by using AI to validate the appropriate use of the language based on *ESSENTIA CURRICULUM*. The successful application of the standard confirms the operational integrity and scholarly validity of our contributions to curriculum design by using *ESSENTIA CURRICULUM*.

7.2 Contributions

The representation of common practices and terminology: An alternative way to retrieve valuable information among empirical practices in curriculum design by using pre-conceptual schemas is proposed. Furthermore, we consider the terminology unification in curriculum design an additional contribution.

A theoretical foundation and application: *ESSENTIA CURRICULUM*, as a theoretical foundation from a software engineering approach based on the SEMAT Essence kernel for curriculum design, successfully extends its applicability beyond computing-related programs, proving its effectiveness in addressing curriculum design in any context.

A methodological approach: The success of this Ph.D. Thesis is attributed to the use of computational linguistics, which provides a sophisticated and efficient means of data analysis. This methodology enabled us to uncover intricate patterns and insights, significantly contributing to the robustness of our results.

A common ground in curriculum design: We propose *ESSENTIA CURRICULUM* as a common ground for curriculum design endeavors, generating more relevance to the freedom of representation of practices instead of static methods.

7.3 Future work

The *ESSENTIA CURRICULUM* model, encompassing its kernel and language specification, can be significantly improved by integrating artificial intelligence into a computing solution. NLP, particularly through training and fine-tuning large language

models, is experiencing a significant developmental milestone in our society. Therefore, developing a computational tool that represents curriculum design practices within *ESSENTIA CURRICULUM* while combining NLP and artificial intelligence would represent a remarkable implementation milestone, drawing upon the extensive theoretical and model frameworks outlined in this Ph.D. Thesis. Further, the generation of a digital repository based on open data policies for publishing the current library of curriculum design practices—*EC-Bibliotheca*, which is based on *ESSENTIA CURRICULUM*—will foster the massive usage of the library. Finally, an “evangelization” process of *ESSENTIA CURRICULUM* in higher education institutions is needed to encourage its usage and appropriation in academic scenarios. Such “evangelization” process can start with a “2nd Call for Action” described in the *EC-Bibliotheca*.

In this way, we propose the following scenarios as future work based on this Ph.D. Thesis. Each of these potential areas of future work could help to further apply this Ph.D. Thesis and expand its applicability and impact within the field of curriculum design.

- Advanced Computational Tools:

Develop more advanced computational tools and algorithms for analyzing the linguistic corpus and automating parts of the curriculum design process. This could involve the use of machine learning techniques to predict effective curriculum design practices based on historical data or the incorporation of AI to provide personalized recommendations for curriculum designers.

- Interactive Platforms:

Create a more interactive and user-friendly platform for *ESSENTIA CURRICULUM* that allows curriculum designers to access the existing library (*EC-Bibliotheca*) and contribute new content, collaborate with peers, and receive feedback. This platform could leverage community-driven features to enhance user engagement and knowledge sharing.

- Real-World Testing and Case Studies:

Conduct extensive case studies in diverse educational settings to validate and refine the *ESSENTIA CURRICULUM*. This would include detailed analysis of the outcomes from these studies to better understand the impact of the curriculum designs generated using the proposal.

- Integration with Educational Policies:

Explore how *ESSENTIA CURRICULUM* can be integrated with national or international educational policies. This involves working with educational policymakers to understand the regulatory and practical requirements for curriculum design and how they can be aligned with the theoretical model.

- Longitudinal Studies:

Initiate longitudinal studies to track the effectiveness of curriculum designs created using *ESSENTIA CURRICULUM* over time. This would provide insights into how these designs perform in the long term and how they influence educational outcomes.

- Scalability and Customization:

Address scalability and customization issues by developing methods within *ESSENTIA CURRICULUM* that can adapt to varying sizes of educational institutions and their specific requirements. This might include modular curriculum components that can be easily scaled or adapted.

A. Annex: Academic productivity associated with this Ph.D. Thesis

International
research internship

Formal System Analysis Research Group
Department of Mathematics and Computer Science
Eindhoven University of Technology
The Netherlands, 2018



Written academic productivity.

Papers:

- “Computers’ Interpretations of Knowledge Representation Using Pre-Conceptual Schemas: An Approach Based on the BERT and Llama 2-Chat Models”, Insuasti, J., Roa, F., & Zapata-Jaramillo, C.M. (2023). *Big Data Cogn. Comput.*, 7(4), 182; <https://doi.org/10.3390/bdcc7040182>
- “Towards Enhanced Programming Pedagogy: Harnessing Computational Linguistics for extending the Didactic Transposition Theory”. Insuasti, J., Zapata-Jaramillo, C., & Barón, A. (2023). Under journal editors review...
- “Experiencing *ESSENTIA CURRICULUM* for representing practices in curriculum design: A case study of the Doctoral Program in Educational Sciences in Colombia”. Insuasti, J., Zapata-Jaramillo, C.M. (2023). Under journal editors review...

Book chapters:

- Zapata-Jaramillo, C., & Insuasti, J. (2018). "Aspectos curriculares orientados a la industria 4.0 en los programas de pregrado relacionados con la computación", in *Industria 4.0: escenarios e impacto*. <https://unilibros.co/gpd-industria-4-0-escenarios-e-impacto.html>

Oral presentations:

- "A first practice in curriculum design represented in a software engineering teaching kernel", Zapata-Jaramillo, C., & Insuasti, J. (2019). In *ABSEL*, March 20-22, 2019, San Diego, CA. <https://absel-ojs-ttu.tdl.org/absel/article/view/3222/3147>
- "A first approach to the representation of the experiential learning practice on top of the Quintessence kernel", Zapata-Jaramillo, C., & Insuasti, J. (2021). In *ABSEL*, March 24-26, 2021, Pittsburg, PA. <https://absel-ojs-ttu.tdl.org/absel/article/view/3299/3233>
- "Computational linguistics supported by neural networks for the detection of textual patterns", Insuasti, J., Zapata-Jaramillo, C., & Bolaños, M. (2023). *Congreso Andino de Computación, Informática y Educación CACIED*, November 8-10, 2023, Pasto, Colombia.
- "Using Artificial Intelligence to Teach and Learn the Formal Languages and Automata Course at the University of Nariño", Insuasti, J., Roa, F., & Zapata-Jaramillo, C.M. (2024). The 12th European Conference on Education (ECE2024), July 11-15, 2024, London, UK.
- "Representing Curriculum Design Practices in *Essentia Curriculum*: A Case Study in the University of Nariño, Colombia", Insuasti, J., & Zapata-Jaramillo, C.M. (2024). The 12th European Conference on Education (ECE2024), July 11-15, 2024, London, UK.

Advising of a M.Sc. Thesis (2023, In progress...)

"NATURAL LANGUAGE PROCESSING IN PRE-CONCEPTUAL SCHEMAS FOR REPRESENTING KNOWLEDGE BY USING LARGE LANGUAGE MODELS"

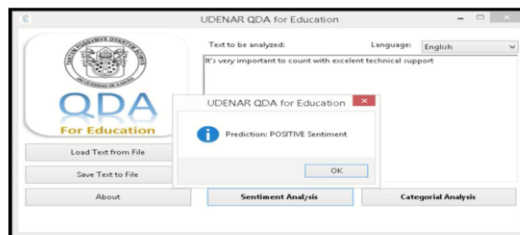
Felipe Roa, B.Sc.

M.Sc. Program in Systems Engineering and Computing
University of Nariño. Pasto, Colombia

Software

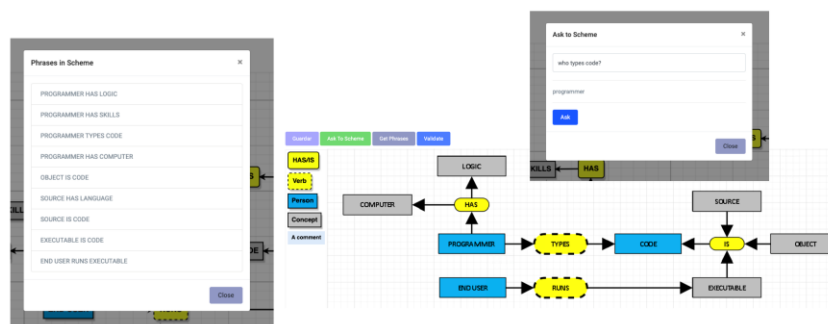
UDENAR QDA for Education

Insuasti, J. & Bolaños, M. *Logical Support Registration # 13-90-72 (01-Jun-2022)*
National Directorate of Copyright - Ministry of Interior, Colombia



PCS-AI v1.0

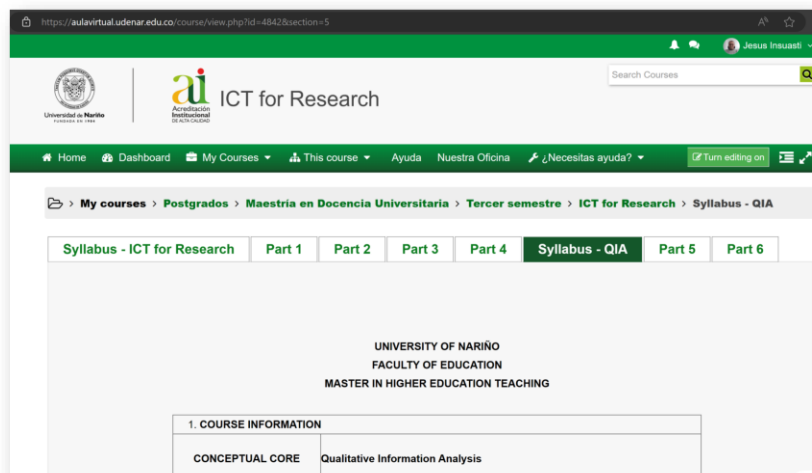
Insuasti, J., Roa, F., & Zapata-Jaramillo, C. (2023) *Logical Support Registration # 13-96-425 (16-Nov-2023)*
National Directorate of Copyright - Ministry of Interior, Colombia



Academic activities derived from this research

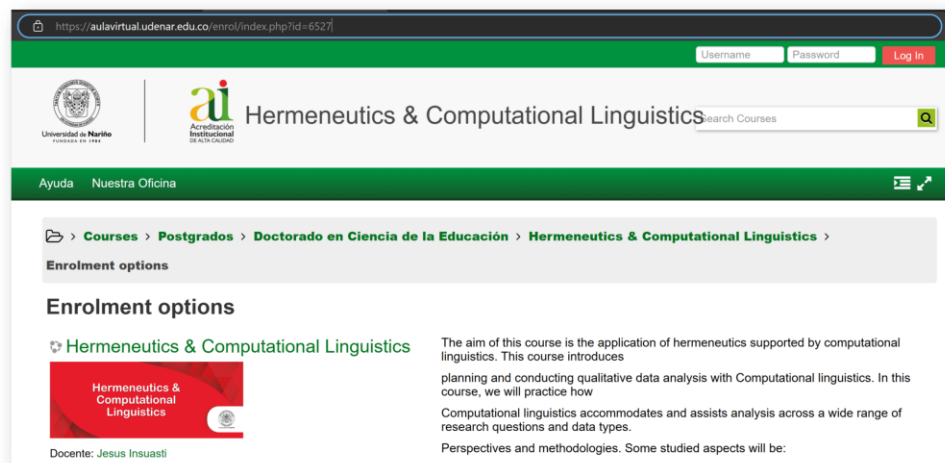
M.Sc. Course (online 2020)

Qualitative Information Analysis & ICT for Research
Master program in Higher Education Teaching
University of Nariño. Pasto, Colombia



Ph.D. Course (2023)

Hermeutics & Computational Linguistics
Ph.D. program in Educational Sciences
University of Nariño. Pasto, Colombia



B. Annex: Practice reinterpretation – From Quintessence to ESSENTIA CURRICULUM

Practice number	Link
1	http://www.essentiacurriculum.net/reinterpretation01.html
2	http://www.essentiacurriculum.net/reinterpretation02.html
3	http://www.essentiacurriculum.net/reinterpretation03.html
4	http://www.essentiacurriculum.net/reinterpretation04.html
5	http://www.essentiacurriculum.net/reinterpretation05.html
6	http://www.essentiacurriculum.net/reinterpretation06.html
7	http://www.essentiacurriculum.net/reinterpretation07.html
8	http://www.essentiacurriculum.net/reinterpretation08.html
9	http://www.essentiacurriculum.net/reinterpretation09.html
10	http://www.essentiacurriculum.net/reinterpretation10.html
11	http://www.essentiacurriculum.net/reinterpretation11.html
12	http://www.essentiacurriculum.net/reinterpretation12.html
13	http://www.essentiacurriculum.net/reinterpretation13.html
14	http://www.essentiacurriculum.net/reinterpretation14.html
15	http://www.essentiacurriculum.net/reinterpretation15.html
16	http://www.essentiacurriculum.net/reinterpretation16.html
17	http://www.essentiacurriculum.net/reinterpretation17.html
18	http://www.essentiacurriculum.net/reinterpretation18.html
19	http://www.essentiacurriculum.net/reinterpretation19.html

C. Annex: Call for Action

Considering your experience in computing-related academic programs, please fill out the form below:

About the scenarios

Please, select all types of curriculum in which you have participated in the design process.

- Personal curriculum (e.g. Individual learning plan)
- Classroom curriculum (e.g. Course Syllabus, Instructional plan)
- Institutional curriculum (e.g. College/School/Dept./Program Curriculum)
- National curriculum (e.g. National Syllabi, National Frameworks, National Guidelines)
- International curriculum (e.g. ACM Computing Curricula, IEEE Computing Curricula, UNESCO)

How do you design a curriculum?

Please, describe what you usually do when designing a curriculum, and mention the curriculum aspects that you consider (for instance: aims and objectives, contents, learning activities, materials and resources, bibliography, assessment, among others.)

When I design a curriculum, I ...

Additional information

If you have any comments based on your experience in curriculum design, please feel free to type them here!

Send

D. Annex: Responses (Excerpt)

A	B	C	D	E	F	G	H	I	J	K	
ID	DATE	EMAIL	PERSON	CLASSROOM	INSTITUTION	NATION	INTERNATION	PRACTICE	COMMENTS	RANK	UNIVERSITY
1	5/27/2020	hgs@cs.columbia.edu	0	1	0	0	0	0	I start from the overall goal ("what key cap it's typically an evolutionary process - existing course	8	Columbia University
2	5/27/2020	cdg@wustl.edu	0	1	0	0	0	0	I plan out what I expect the students to learn in the course, how to evaluate their progress in	22	Washington University
3	5/27/2020	deena@cs.nyu.edu	0	1	0	1	0	0	I organize materials around - course desc It is very important to get feedback during the curr	30	New York University
4	5/27/2020	suzanne.m.embury@manchester.ac.uk	0	1	0	0	0	0	I consider the intersection between the parts of the academic discipline that are well-defined	33	The University of Manchester
5	5/27/2020	clayton.lewis@colorado.edu	1	1	1	0	0	0	I think about what the students need to know Many students, though of course not all, have resp	39	University of Colorado
6	5/27/2020	kamin@illinois.edu	0	1	1	0	0	0	It depends: For institutional curriculum, I would only mention that in my experience design	40	University of Illinois
7	5/27/2020	ncorrell@colorado.edu	1	1	1	0	0	0	I try to identify the overarching learning goals Although I know how to formally approach this pro	39	University of Colorado
8	5/27/2020	zmenadic@uci.edu	0	1	0	0	0	0	I Google what professors at top places use and add/subtract.	80	University of California
9	5/27/2020	germano@cs.ucl.ac.uk	1	1	1	0	0	0	I find a compromise between my personal opinion and external constraints: for a personal cur	15	University College London
10	5/27/2020	stark.draper@utoronto.ca	1	1	1	1	0	0	I am motivated by the ideas I see my students need but are not currently exposed to. I am in e	24	University of Toronto
11	5/27/2020	p.klehre@cs.bham.ac.uk	1	1	1	0	0	0	I have followed acm curriculum review	134	University of Birmingham
12	5/27/2020	o.diesel@unsw.edu.au	1	1	1	0	0	0	I define the long-term objectives for the student and client groups, determine the gaps that ex	94	The University of New South Wales
13	5/27/2020	pat.pang@unimelb.edu.au	0	1	0	0	0	0	Contents, learning activities, materials and resources, assessments	41	The University of Melbourne
14	5/27/2020	emil@mcmaster.ca	1	1	1	1	0	0	1) study other successful curriculums 2) use my experience with what works in this particular	91	McMaster University
15	5/27/2020	h.muller@leeds.ac.uk	0	1	1	0	0	0	I agree with colleagues. Together we consider aims and objectives, contents, learning activities	139	University of Leeds
16	5/27/2020	matty@ece.ubc.ca	0	1	1	0	0	0	I follow the learning objectives, and layout I do all the video recording on the lightboard. See t	36	University of British Columbia
17	5/27/2020	hgata@unsw.edu.au	0	1	1	0	0	0	I consider the core competencies the grad work in a relatively new interdisciplinary field (Bio	94	The University of New South Wales
18	5/27/2020	helleman@email.arizona.edu	1	1	1	0	0	0	All curricula should be designed by considering the student's perspective. We recently complet	132	University of Arizona
19	5/27/2020	jijin@tsinghua.edu.cn	0	1	1	0	0	0	I bear in mind the aims and objectives and it would be helpful to make a curriculum self-conta	43	Tsinghua University
20	5/27/2020	khoo@comp.nus.edu.sg	0	1	1	0	0	0	I look into the learning outcome: get course There are some standard on how to assess curricu	67	National University of Singapore
21	5/27/2020	tan@comp.nus.edu.sg	0	1	1	0	0	0	I need to consider the following: a) aims and objectives: what's the purpose of the module/pr	67	National University of Singapore
22	5/27/2020	spencer.rugaber@cc.gatech.edu	0	1	1	0	0	0	Incremental refinement from existing version. Specific issues include synchronizing content wi	108	Georgia Institute of Technology
23	5/27/2020	e.dunne@liverpool.ac.uk	0	1	1	0	0	0	I consider (for course level) 1. Content 2. Aims 3. Syllabus organisation 4. Prerequisite needs. F	148	University of Liverpool
24	5/27/2020	eyak@cs.technion.ac.il	0	1	1	0	0	0	When I design a classroom curriculum, I mention the aim and objectives, an overview of the co	86	Technion-Israel Institute of Technology
25	5/27/2020	ramin.yahyapour@gwdg.de	0	1	1	0	0	0	I first summarize the expected learning goals from the curriculum. I take a review from the c	138	University of Göttingen

...

A	B	C	D	E	F	G	H	I	J	K	
ID	DATE	EMAIL	PERSON	CLASSROOM	INSTITUTION	NATION	INTERNATION	PRACTICE	COMMENTS	RANK	UNIVERSITY
202	6/7/2020	mbkj@miami.edu	1	1	1	0	0	0	I consider the aims and objectives and then match that with content, learning activities and ty	386	University of Southern California
203	6/7/2020	mehdi.jazayeri@usi.ch	1	1	1	0	0	0	I decide on the learning objectives, fundam It is now possible to find sample courses on the int	565	Università Della Svizzera
204	6/8/2020	maura.cerri@unige.it	0	1	1	0	0	0	At the classroom level I try to build a path I found a course I attended several years ago on ins	470	University of Genoa
205	6/8/2020	jmcg1@um.es	0	1	0	0	0	0	I firstly need to follow the higher level guidelines coming from the degree programme. It mea	785	University of Murcia
206	6/8/2020	heyer@informatics.uni-leipzig.de	0	1	1	0	0	0	I try to combine available capacities (who can teach what) with the mainstream of the subject	275	University of Leipzig
207	6/8/2020	ji@di.uminho.pt	1	1	1	0	0	0	It depends on the particular curricula. The main aspect is to consider what the learning objecti	477	University of Minho
208	6/8/2020	moross@fin.edu	1	1	1	0	0	0	I usually follow a backward course design model that considers the outcomes first, then asses	416	Florida International University
209	6/8/2020	armitage@usf.edu	0	1	1	0	0	0	I take into account the institutional aims of the program, if applicable. For example, I was invo	282	University of South Florida
210	6/8/2020	yann-gael.gueheneuc@concordia.ca	1	1	1	0	0	0	For graduate students, I talk a lot with the student to assess her strengths and weaknesses as	812	Concordia University
211	6/8/2020	sitsao@cs.nctu.edu.tw	0	1	1	0	0	0	We first do a current student survey, student assessment, understand future needs/targets/si	532	National Central University
212	6/9/2020	andrew.hamilton-wright@uoгуelph.ca	1	1	1	0	0	0	I begin with the learning goals of the discipline's difficult, and requires regular re-evaluation. I th	368	University of Guelph
213	6/9/2020	ef@csd.usf.edu	0	1	1	0	0	0	I follow the steps: 1) Consider the audience A common mistake is to start building a curriculum	401	Aristotle University of Thessaloniki
214	6/9/2020	oivak@comp.nus.edu.sg	0	0	1	0	0	0	When I design a curriculum, I consult the experts, either individual experts in a topic, or insti	67	National University of Singapore
215	6/9/2020	pc@ecog.toronto.edu	0	1	1	0	0	0	Aside from the aspects that are listed, my course also has a weekly laboratory, so it is import	24	University of Toronto
216	6/9/2020	zwhitten@vcu.edu	0	1	0	0	0	0	I take the standards and topics which I am I take great pains to make sure students can follow	294	Virginia Commonwealth University
217	6/10/2020	ko@ukm.edu.my	0	0	1	0	0	0	Program design and delivery of education: Curriculum design has been formulated and reflex	537	National University of Malaysia
218	6/10/2020	pluhar@inf.u-szeged.hu	0	1	1	0	0	0	I try to follow established standards that I "A beginning is the time for taking the most delicat	693	University of Szeged
219	6/10/2020	gkapi@cs.ucy.ac.cy	1	1	1	0	0	0	I consider relevant guidelines (e.g. from IEEE). For personal or class curriculum, I consider also	669	University of Cyprus
220	6/10/2020	boylard@uw.edu	0	1	1	0	0	0	I think about what I want students to learn My approach is rather ad hoc.	492	University of Wisconsin
221	6/11/2020	minges@inf.u-szeged.hu	0	1	1	0	0	0	I usually take into account the following: - What are the legal requirements for that curriculum	693	University of Szeged
222	6/14/2020	irina.golitsyna@kpfu.ru	0	0	1	0	0	0	I usually consider aims and objectives, contents, learning activities, materials and resources	833	The National University of Science and Technology
223	6/15/2020	anthony@cs.otago.ac.nz	0	1	1	1	0	0	I - Look for any existing guidelines, e.g. the ACM computing curriculum guides: https://www.acm.org/curriculum	379	University of Otago
224	6/17/2020	dmdh@uic.edu	0	1	0	0	0	0	When I design a curriculum, I would follow I think it is important to follow evidence-based app	270	University of Illinois at Chicago
225	6/29/2020	j.groote@tue.nl	0	1	1	0	0	0	There are two important aspects. The first one is to ask what students are supposed to know	316	Eindhoven University of Technology
226	6/30/2020	pnevmat@cslab.ece.ntua.gr	0	1	0	0	0	0	When I design a curriculum, I consider aims and objectives market/employability trends techn	643	National Technical University of Athens
227	7/7/2020	gibong@hotmail.com	1	1	1	0	0	0	When I design a curriculum I first consider the desired egress profile for students, then, from t	818	Federal University of Rio de Janeiro

E. Annex: INFORMED CONSENT FOR PARTICIPATION IN RESEARCH

INFORMED CONSENT FOR PARTICIPATION IN RESEARCH

Study name :

Name of the researcher:

Profession_Position :

Contact: email –
telephone _____

You have been invited to participate in a research study. Before you decide to participate, please read this consent carefully and ask any questions you need so that you understand what participation in the research entails.

The study is titled

“ _____

The objective of the study

is _____

Voluntariness and confidentiality: Participation in the research is completely voluntary. By signing this informed consent, you are authorizing the information to be used for the aforementioned research purposes, so it will not be used for any other purpose.

The information will be completely confidential, and your identity will not be revealed in any media. From the moment the information is systematized (it is typed and organized to be able to study it) your name is removed from the files and will only be known to the researcher(s).

The data generated from this project will be presented in national publications and, if possible, in international publications, always preserving your identity, that is, maintaining the confidentiality of your personal data.

Benefits and risks : If you decide to participate in this research, you will not receive any financial benefit, but you will not have to assume any costs associated with your participation.

As proof that I have understood the objective, the conditions and all doubts that arose regarding my participation in the research were clarified, and I agree, I sign this informed consent in the city of _____, on _____ of _____, 20 ____

Name of participant _____

Signature _____

References

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