# A First Practice in Curriculum Design Represented in a Software Engineering Teaching Kernel

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## ABSTRACT

*In the educational setting, several methods are used for curriculum design. Despite the existence of such methods, a sample of documented experiences about curriculum design shows their designers use their own criteria. Also, the usage of heterogeneous practices and diversity of concepts, and different ways of working in curriculum design are detected in the curriculum design endeavor. In order to alleviate such situations, in this paper a common ground for curriculum design affairs based on a Software Engineering Teaching kernel is used. A kernel is defined as a set of concepts and relationships which are essential and are present in any software development effort. In this proposal, the usage of such a kernel is just the first step in order to think about practices and methods for curriculum design. The Software Engineering Teaching kernel we use for representing our first practice in curriculum design is derived from a general theory called SETMAT−Software Engineering Teaching Methods and Theory. The contribution in this regard is based on exploring alternative ways of working with curriculum design from an engineering perspective.*

## INTRODUCTION

A method is a systematic procedure, technique, or way of inquiry employed for a particular field of knowledge. In the educational scenario, methods are used for creating curriculum designs for academic programs (O'Neill, 2015). According to a state-of-the-art review, several methods for curriculum design are identified (UNESCO-IBE, 2013).

Even though the identified methods for curriculum design are documented in such a state-of-the-art review, findings on experiences in curriculum design show designers use their own criteria. According to such findings, each designer has particular practices different from the ones proposed by others; hence, designers work with curriculum design in different ways. In addition, designers have their own concepts about what a curriculum should be. Facing this panorama, we think heterogeneous practices in curriculum design are the cause of some problems: (i) the prevalence of isolated practices in curriculum design rather than an engineering discipline leads to many ways of working, so sharing valuable information among such practices is difficult; (ii) in some curriculum design, there is a lack of documentation of the process, so, a risk of losing knowledge in this regard can arise; (iii) observable and reliable verification about practices for curriculum design from an engineering perspective is lacking.

Given such problems, a common framework for curriculum design could be useful. In this instance, the first step in achieving a unified framework is terminology unification. Cabré (2010) states "terminology, conceived as the set of the lexical units used with a precise value in a field of specialty, is an indispensable resource to represent and communicate a specialized knowledge." Fortunately, a first attempt at terminology unification in education from a software engineering perspective has been made in SETMAT (Gómez, 2018). SETMAT stands for Software Engineering Teaching Methods and Theory. Gómez (2018) looks for supporting the teaching labor in the selection of teaching strategies for software engineering by using SETMAT. Despite SETMAT is focused in software engineering teaching, both the terminology unification and the kernel are highly valuable for curriculum design affairs.

According to OMG (2015), a practice is a repeatable approach to doing something with a specific objective in mind. We call this first attempt of curriculum design representation as practice. In this paper we propose a first practice in curriculum design supported by the SETMAT kernel. SETMAT, in addition to incorporating new elements in its Semat-Essence-based kernel, involves elements of the software engineering teaching process according to the three definitions below.

> "Alphas. Representations of the essential things to work with. The alphas provide descriptions of the kind of things that a team will manage, produce, and use in the process of developing, maintaining, and supporting software and, as such, are relevant to assessing the progress and health of a software endeavor. They also act as the anchor for any additional sub-alphas and work products required by the software engineering practices.
> Activity Spaces. Representations of the essential things to do. The activity spaces provide descriptions of the challenges a team faces when developing, maintaining, and supporting software systems, and the kinds of things that the team will do to meet them.
> Competencies. Representations of the key capabilities required to carry out the work of software engineering." (OMG, 2015).

This representation of the practice in curriculum design includes a common language for designers to represent, compare and transfer their practices into curriculum design. Also, this first practice helps to identify the minimum elements that should be linked to any curriculum design method.

This paper has 6 Sections. The first one has an explanation of the study context. The second one has a description of the findings in the field of knowledge related to curriculum design, including the problem statement. The third one contains the formulation of the proposed solution by using the SETMAT kernel. The fourth one has a description of the benefits of such proposed solution. Conclusions are presented in the fifth Section. Finally, we propose future work from the present study in the last Section.

## CONTEXT

Each academic program has a curriculum, which is designed according to the designer own criteria. By considering a state-of-the-art review, some methods for curriculum design are found (see Table 1); however, documented experiences on curriculum design for such programs are done in a non-standardized way. In this regard, immature practices have been identified in curriculum design. In educational affairs, some methods for curriculum design have been raised. A sample of 25 proposed methods is depicted in Table 1.

### EXHIBIT 1
### TABLE 1. SAMPLE OF METHODS OF CURRICULUM DESIGN (SOURCE: THE AUTHORS)

| Author | Year | Method's name for curriculum design |
|---|---|---|
| Bobbitt, F. | 1924 | Bobbitt's method for creating a curriculum |
| Tayler, R. | 1949 | Tyler's model for curriculum design |
| Smith, B., Stanley, W., & Shores, J. | 1957 | Society-centered model |
| Taba, H. | 1962 | Taba's model for curriculum development |
| Lamm, Z. | 1963 | Lamm's model |
| Maccia, E. | 1965 | Maccia's model |
| Davis, S. | 1965 | Persistent life situations curriculum |
| Taylor, C. & Harding, H. | 1967 | Model for curriculum reform |
| Wheeler, D. | 1967 | Wheeler's process model |
| Halliwell, H. | 1968 | Halliwell's curriculum process |
| Kerr, J. | 1968 | Kerr's model |
| Nicholls, A. & Nicholls, H. | 1972 | Curriculum model of Nicholls & Nicholls |
| Stenhouse, L. | 1975 | Curriculum research and development |
| Hall, G. | 1976 | Competency-based curriculum design |
| Grayson, L. | 1978 | Grayson’s methodology for curriculum design |
| Reeves, G. & Jauch, L. | 1978 | Curriculum development through Delphi |
| Walters, S. | 1978 | Walters' model for curriculum design |
| Spady, W. | 1993 | Outcome-based education |
| Wiggins, G. & McTighe, J. | 1998 | Backward design |
| Kern, D. *et al*. | 1998 | A 6-step approach for curriculum development |
| Akker, J. | 2009 | Curriculum design research |
| Thong, C. *et al*. | 2012 | Maturity model for curriculum design |
| Nunley, K. | 2014 | Layered curriculum |
| Perovic, N. & Young, C. | 2015 | ABC curriculum design method |
| International Bureau of Education-UNESCO | 2017 | Curriculum framework |

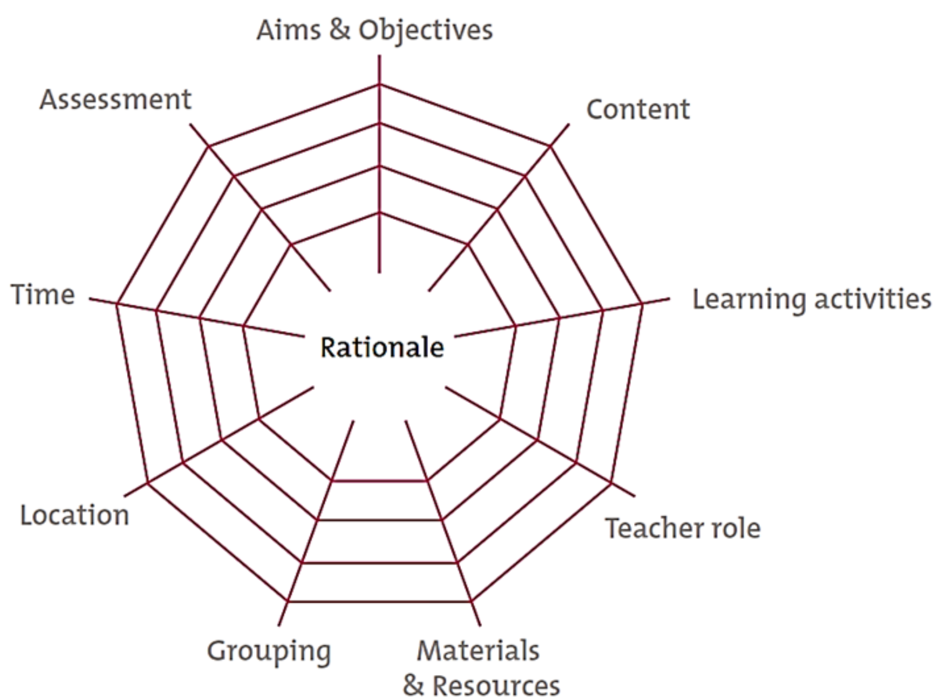
Curriculum designers are free to adapt their way of working in matter of curriculum design. Given such freedom, some designers start their labor having different conceptions about the very concept of curriculum itself. For instance, some of them do their designs only focused on the structure of contents; other ones work with contents and teaching-learning strategies. Curriculum design depends on what type of curriculum product is being expected; hence, the concept of curriculum product is becoming important. According to Akker (2006), some curriculum products are related to curriculum design, and such products depend on the level of appliance. Examples of curriculum products are depicted in Table 2.

## EXHIBIT 2
## TABLE 2. CURRICULUM LEVELS AND CURRICULUM PRODUCTS (SOURCE: AKKER, 2006)

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

In addition, Akker (2006) introduces the concept of educational aspects to be considered in a curriculum design. Such educational aspects are strictly related to curriculum products. Educational aspects are the essential components in the rationale about curriculum design. They can be expressed as a curricular spider web as shown in Figure 1.

## EXHIBIT 3
## FIGURE 1. THE CURRICULAR SPIDER WEB (AKKER, 2003)




Every single educational aspect matters in a curriculum design endeavor. In order to consider educational aspects, curriculum designers should raise some questions focused on the students: why are they learning? (rationale), which goals are they learning towards? (aims and objectives), what are they learning? (content), how are they learning? (learning activities), how is the teacher facilitating their learning? (teacher role), what are they learning with? (materials and resources), whom are they learning with? (grouping), where are they learning? (location), when are they learning? (time), how is their learning assessed? (assessment).

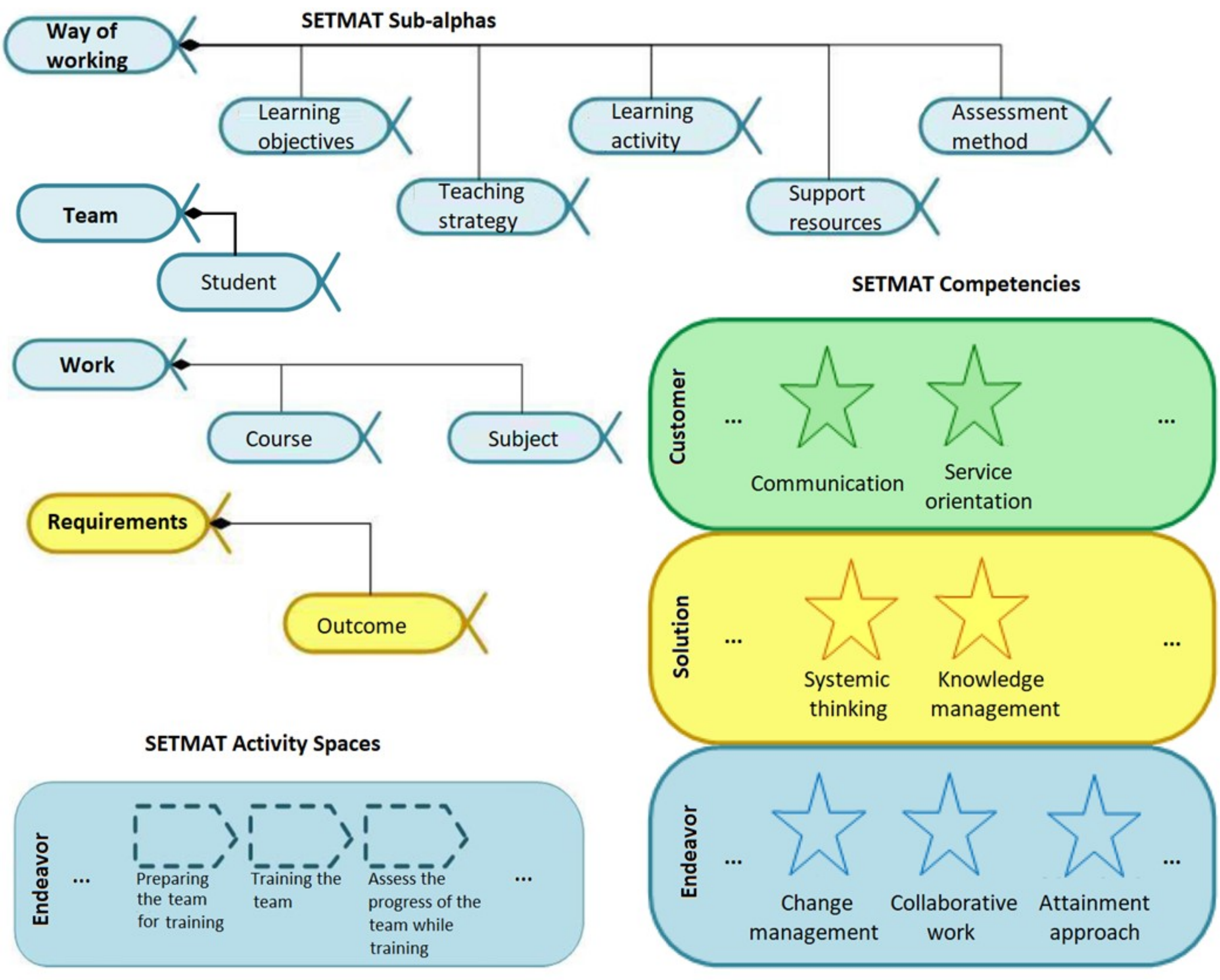
In this vein, curriculum design is more than an activity to create a course structure for a program. Several educational aspects such as pedagogical models, teaching-learning strategies, assessment activities, and so on, should be considered in addition to the specification of a course structure (Navarro, Foutz, Thompson, & Singer, 2016).

## FINDINGS ON CURRICULUM DESIGN

Despite the existence of methods for curriculum design, the following review of 10 chronologically-ordered, documented experiences have shown designers use their own criteria, ignoring such methods for curriculum design, and dealing with some educational aspects.

1. Conceptions about how to design a curriculum in a computing-related program depend on designers. Sometimes, the method itself is very important for some of them. Such is the case of a proposal with graphical representations pointing towards establishing design criteria as educational perspectives (Krassowski *et al.*, 1999). In such a proposal, authors emphasize the importance of defining the method for designing a curriculum in first instance, rather than directly entering to the curriculum design itself.
2. A synergistic interaction model is proposed by Desai and Embse (2001). In such a proposal, the educational institution interacts with business organizations for defining the main topics to be considered into the curriculum. The authors use Venn Diagrams for such purpose. Such a proposal involves just one educational aspect related to contents and their intersections in the fields of knowledge.
3. 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

**EXHIBIT 4**
**FIGURE 2. SETMAT ELEMENTS (TRANSLATED FROM GÓMEZ, 2018)**




Translated from (Gómez, 2018)

construction and the sequential representation of the courses in the program.

4. Focusing on content, another way to represent a curriculum is based on a flow-path diagram. In such a diagram, students advance in their educational process by following such a path (Ehie, 2002). Such a curriculum proposal includes contents and course sequences.
5. A block diagram can be useful for defining a course structure; so, a curriculum is proposed by using such a diagram (Golden & Matos, 2006). In such a proposal, just the course structure as educational aspect is used.
6. Another proposal is a layer-based architecture with representation in blocks (Ding *et al.*, 2011). Such a proposal includes one educational aspect related to contents in the course schema.
7. A proposal for standardizing a new undergraduate curriculum for information technology degree was conceived by using a progress graph for representing the course structure. Such a proposal is based on nodes as courses and arrows as the sequential path among them (Wang, Huang, & Liu, 2011). Just the course structure as educational aspect is used.
8. A project-based curriculum has been defined by describing a sequence of courses (Martinez & León, 2012). The term "distance" is conceived for measuring similarities among Bodies of Knowledge—BOK—on the covered topics. The course structure as educational aspect is used in such a proposal.
9. Another experience is a curriculum based on a graph chart with connected nodes and tabular descriptions (Cuadros-Vargas *et al.*, 2013). Course structure as educational aspect is just considered in the graphical representation of the sequential path.
10. A block-based diagram for course structure is proposed. Blocks grouped by components represent the course structure in such a proposal (Villapol *et al.*, 2013). Course structure as educational aspect is just included.

This state-of-the-art review helps to evidence heterogeneous practices, which use diversity of concepts and include different ways of working in curriculum design. Facing such a behavior related to heterogeneous practices, we propose a first practice in curriculum design in the next section.

## PROPOSED SOLUTION

According to the above, we take advantage of the SETMAT definition proposed by Gómez (2018) in our proposal. In such a definition, the Semat Essence kernel is used with additional elements of the teaching process in software engineering. With this, we use the additional elements proposed by Gómez (2018) because they are useful items for defining teaching practices. Such additional elements are depicted in Figure 2.

Considering the sample of methods of curriculum design depicted in Table 1, SETMAT elements are suitable for proposing a very first practice in curriculum design which is common in most of such methods. We are talking about the first step in curriculum design related to gathering the needs of the context. In this regard, Bobbitt (1924) and Tyler (1949) start with the problems of the American society of his time: industrialization and the impacts of world wars; Taba (1962) promotes the diagnosis of context based on research activities focused in the needs of people as the first step for curriculum planning; Stenhouse (1975), criticizing the educational technology model focused in agriculture development, proposes to involve an experimental approach from the realities of the environment to develop useful skills according to the context; Grayson (1978) explicitly emphasizes on the mission statement, industry needs, societal needs, and professional needs as the starting point in curriculum design; Walters (1978) states "All curricula contain certain common elements. Analysis shows that these are an aim or aims, subject matter, assessment of the attainment of the aims and/or the mastery of the subject matter by the students", and such common elements should be focused on the needs of the context; Spady (1993) states that student outcomes are directly related to context which was seen in the curriculum design at the first instance; Kern and others (1998) define their first step in curriculum design as problem identification and general needs assessment; Wiggins and McTighe (1998) begin their proposal from the identification of desired results based on the needs of the context; Finally, UNESCO-IBE (2017) defines as a first stage the gathering of evidence about context, "to increase participants' understanding of the benefits and costs of developing a curriculum framework; and to apply such understanding to their own contexts".

Taking into account the previous concepts about the needs of the context, our first practice in curriculum design is conceived to gathering such needs. The representation of our first practice in curriculum design is called "gathering the needs of the context", and it is represented by using the Semat Essence language with the additional elements according to SETMAT. Such a representation is depicted in Figure 3.

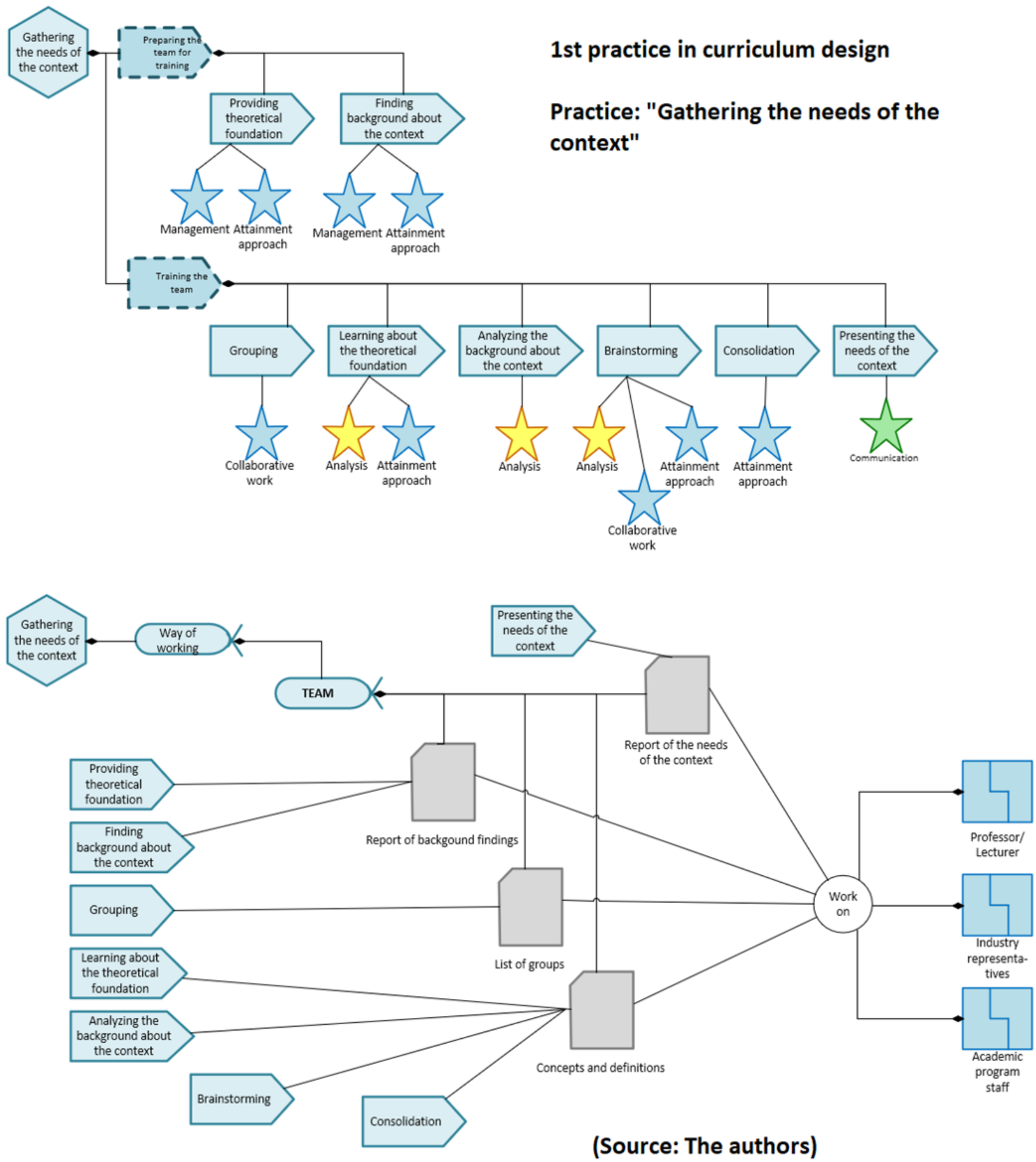
## BENEFITS OF THE PROPOSAL

A first attempt for representing a common practice by using SETMAT is proposed in this paper. The Semat Essence language helps to document the processes related to curriculum design. Then, an alternative way to retrieve valuable information among empirical practices in curriculum design is proposed. On the other hand, we also expect providing sound evidence by using the Semat Essence language in a scenario beyond software engineering. We consider this a valuable experience for enriching the usage of such a language due to its versatility.

This first representation of a practice in curriculum design demonstrates the three characteristics of the Semat Essence kernel: Actionable, extensible, and practical. In our first practice we deal with alphas and sub-alphas defined in SETMAT from the Semat Essence kernel; also, SETMAT elements are an extension of such a kernel, and we identify a common practice which is described in most of the sample of methods in curriculum design, so we have the opportunity to represent such a practice taking advantage of the philosophy behind Semat Essence.

In this vein, any kind of practices related to curriculum design can be represented in the way we do. This feature could be beneficial when sharing information about the design of curriculum practices using a common language.

## EXIBIT 5
## FIGURE 3. PRACTICE "GATHERING THE NEEDS OF THE CONTEXT" (SOURCE: THE AUTHORS)



# CONCLUSIONS

In this paper, we present a first practice in curriculum design represented in the Semat Essence language by involving the new elements of the SETMAT proposal. According to the reviewed sample of method of curriculum design, several ways of working are arisen; ergo, heterogeneity in the curriculum design makes difficult to share and adapt common practices in different contexts.

According to the linguistic rules of the usage of the Semat Essence language and the general-purpose of its elements, the representation of any type of practice in curriculum design is possible. We select a first common practice that is usually involved in the early stages of most curriculum design methods, in order to demonstrate the feasibility of implementing designs through Semat Essence in companion with the SETMAT elements.

# FUTURE WORK

The work related to curriculum design is quite complex. This proposal is just the first practice in curriculum design by using the Semat Essence language involving additional elements defined in SETMAT. In order to establish a sound theoretical foundation in curriculum design from a software engineering approach, an entire modified kernel is required. A brand-new kernel for curriculum design could be a valuable starting point to describe practices and methods in curriculum design. In this vein, our next step is to establish the common elements in curriculum design to build such a kernel. Furthermore, a set of common practices in curriculum design should be identified.

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