Towards Deep Learning in the University through Collaborative Instructional Design based on Learning Outcomes and Threshold Concepts

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Abstract: This article presents a proposal for the development of a collaborative curriculum and instructional design at the university. It starts from the premise that teaching-learning processes at any level of training must be designed, managed and implemented in a collaborative way, supported by teacher structures grouped around their domains of knowledge. Moreover, we consider as central axes of all curricular and instructional design a correct selection and structuring of the contents to be studied, based on the identification of the conceptual structures of the topics under study (threshold concepts and their interlinkages) together with an appropriate definition of the desired learning outcomes and evaluation tools.

1 INTRODUCTION

Today's society is characterized by the preponderance that information and knowledge have taken in the generation of wealth and in the very development of social and economic life (North et al., 2018). This has been favored by advances in information and communication technologies, mobile systems, microelectronics, and greater storage capabilities, processing and access to data almost ubiquitously. This technological evolution leads us to a potentialization of the world of work, allowing the execution of more complex tasks and the automation of routine processes. This reality leads people and organizations to carry out their activities in an environment of high volatility, uncertainty, complexity and ambiguity (Bongiorno et al., 2018), which in turn implies a change in the structure and future of work (Steiner, 2020). Thus, greater competitive advantage is given to those with the ability to learn (Rimbau, 2013) and skills for creativity, innovation, imagination and design (Brown et al., 2017): the so-called knowledge workers.

As can be seen, this new social situation creates a series of challenges for workers and for their training (North et al., 2018). We need professionals with a deep understanding of the main concepts that structure their disciplines, enabling them to act on the basis of that knowledge, moving from knowledge to competence, and from competence to action; with a training that allows them to be aware of the complexity of the environment, and of learning as a means to deal with it. From this perspective, it is clear that contemporary society is affecting the university, as a social organization, in all its organizational structure, processes and in the organizational culture itself. On the

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one hand, the training requirements of students and professionals have changed drastically, but, above all, they are highly dynamic. For example, in the field of engineering, especially those related to electronics, telecommunications and computing, the rate of technological change is such that it is impossible to cover it completely during a four-year training period (Kaynak and Sait, 2020).

In this same environment of uncertainty, university teaching must change in order to adjust and anticipate the needs of those who are not just students, but extend to society as a whole and its institutions. Teachers are committed to developing skills for interaction and knowledge generation in a distributed way, based on networking, and with local and global collaborative groups; which, in turn, involves extending their skills to manage diversity; and, finally, the capacity for constant learning and innovation (North et al., 2018). Similarly, as teachers, we face, from the educational point of view, generations of students with characteristics not seen in previous periods (Moore et al., 2017) and that lead to teaching and learning being rethought. We are facing students accustomed to immediacy in information and results; with technology as an environment of natural interaction, and without the ability to approach information in depth (Beamish, 2016).

Thus, in recent years, there has been a great interest in the academic community for a series of methodological strategies to enrich teaching processes in the field of science and engineering to stimulate students' deep learning (Graham, 2018; Finelli and Froyd, 2019). Within this background of research, based on the recommendations made by the American Society of Engineering Education, in conjunction with other organizations, three critical areas are proposed that should be addressed (Finelli and Froyd, 2019): (i) improve student learning in undergraduate engineering education, (ii) improve and diversify the paths of engineering students to increase retention, and (iii) use technology to improve learning, and participation and commitment in engineering.

Our interest is mainly focused on generating contributions in the first critical area. So, starting from the question, who and what should we change in our work to improve learning in undergraduate engineering education?, (Finelli and Froyd, 2019) propose four directions for action: (i) change of organizational culture, (ii) research into effective evaluation practices, (iii) promote the adoption of research-based teaching practices, and (iv) characterize the development of successful faculties. In this sense, these authors show that in the literature there is a large set of research (Umbach, 2007; Elrod and Kezar, 2017) that relates the decisions and practices of instruction and evaluation with aspects of the organization (departments, faculties, association of teachers): teachers tend to generate a common practice. This aspect is shown as an important point, and even a barrier to overcome, when generating changes in higher education. Thus, in accordance with this vision, this work, in the first instance, seeks to analyze a new form of organizational structure, the so-called "teacher cloister", as a central axis in the deployment of strategies for the promotion of students' deep learning.

Regarding research on effective evaluation practices, several studies show the importance of formative evaluation (Irons, 2007; McTighe and Wiggins, 2012; Qadir et al., 2020), feedback (Limniou and Smith, 2014; McConlogue, 2020) and remediation (Karpicke, 2017) as strategies to improve student learning. However, it is clear that the desired learning outcomes need to be articulated so that they are clearly known by students (Finelli and Froyd, 2019) and that, in addition, those outcomes to guide the entire learning process (Biggs and Collis, 2014). This step is fundamental and must be supported by a wide range of professionals who define these outcomes (Finelli and Froyd, 2019). In line with the above, appropriate tasks and assessment tools should be designed so that students can demonstrate the extent of the proposed outcomes. In this sense, our proposal shares the criteria of (Biggs and Collis, 2014) and (McTighe and Wiggins, 2012) regarding the centrality of evaluation to improve the performance and learning of students; but, we consider it transcendent that, in addition to the evaluation criteria and instruments, the instructional design must be based on a structuring of knowledge, based on the threshold concepts of each discipline and its relationships.

In this context, the organizational structure of the university, in particular the organisation of teaching staff, and instructional design for the training of future professionals should be rethought to provide an education that enables students to achieve deep learning and the skills needed to manage complexity and uncertainty; while implementing a collaborative and transdisciplinary teaching and learning process. That is, the teaching process cannot be seen as an individual activity of each teacher, disconnected from the activity of the other teachers of the degree; but must be assumed as a collective action. From our point of view, an instructional design based on results-based pedagogical actions (Biggs, 2011; Biggs and Collis, 2014) and on threshold concepts (Stern et al., 2017), and supported by a teaching structure that stimulates joint instructional design and collaborative teaching can enhance deep learning (Biggs and Collis, 2014) of university students.

This article is organized as follows. In Section II, we present the main foundations that support our proposal of instructional design and collaborative teaching, focusing on the conceptualization of "teacher cloisters" and pedagogical proposals based on learning outcomes and threshold concepts. Then, in Section III, we briefly describe the interactions that are presented in curriculum design between teachers and students. Finally, Section IV concludes the paper and points out some lines of future work.

2 BACKGROUND

As discussed in the previous section, our instructional design proposal is based on two key aspects: (i) a collaborative teaching process through the organization of teachers' work in the so-called "teacher cloisters" and (ii) the structuring of knowledge and the design of the teaching and learning process based on learning outcomes and threshold concepts. In this section, we will address the main features of these two aspects.

2.1 Areas of Knowledge and Teacher Cloisters

In general, areas of knowledge can be seen as a way to organize the university's teaching staff. For example, in the case of the Salesian Polytechnic University of Ecuador (UPS), where this vision was implemented, previously, teaching staff gathered around careers and faculties, but this distribution generated a partial view of knowledge; In addition, it was intended to generate rivalries between faculties, a sense of belonging to the faculty and not to the university, as well as an underutilization of teaching resources and capacities. In this context, the idea of areas of knowledge is the grouping of teachers not by faculties but by the area of science in which they specialize. In this way, the human capital of the university can serve all the careers and/or projects that are generated (research, curricula, postgraduate, etc.). It should also be noted that the multidisciplinary and transdisciplinary nature is directly present in the project under implementation, which does not represent a faculty but the university, and in which the professors will intervene from the multiple areas.

Within these macro structures of educational organization, teachers are subdivided into teacher cloisters, made up of those teachers who belong to a specific domain of knowledge within the broad field of the area. In turn, these cloisters incorporate research groups and/or educational innovation groups. For example, again, with regard to UPS, the Teacher Cloister of Telecommunications brings together the Research Group on Telecommunications and Telematics (GITEL), with its lines of research: telemedicine, e-learning, e-agriculture, optical communications, wireless communications; and the Group on Educational Innovation in Telecommunications (GIET), with its lines of innovation and action: design of learning methodologies, generation of teaching materials, shared evaluation methodologies, evaluation of teaching actions, coordination of subjects associated with their field of study (this allows the cloisters to relate to the undergraduate and postgraduate careers that require their services).

Note at this point that the management of teaching and learning supported by the cloisters allows teachers to find a natural space for their research activities within research groups and for innovation in their teaching, through educational innovation groups. Of course, for this to make sense, there is a coordination structure between the faculty and the directors of the innovation and research groups. This allows direct interrelationships between innovative educational and research processes to be generated, and students can be involved in the research carried out by these groups, since they are invited to participate in ad hoc research projects, with which research and teaching are interrelated and support the learning of students.

2.2 Learning Outcomes and Threshold Concepts in Instructional Design

In the development of university teaching, and in general of any of the levels of formation, one of the fundamental tasks corresponds to the instructional design of the courses to be imparted. This activity is key to student learning because it clearly defines the learning objectives and the processes, tools and materials that will be applied to achieve them. Moreover, our choices in design will be the result of the different conceptions, conscious or unconscious, that we possess about what teaching means. This also applies to our and the students' understanding of learning (Biggs, 2011). For example, from a superficial view of learning students intend to execute their tasks with minimal effort, with the apparent view that they meet the requirements of the course. This also leads to students using low-level cognitive abilities, rather than high-level ones when they are required. However, this way of conceiving learning is closely linked to the teaching process. From a superficial perspective, teaching is seen as the delivery of content in the form of lists, without showing an intrinsic structure of the topics; with evaluations focused, in the same way, on independent facts. On the contrary, a deep approach to learning presents students who seek to meaningfully appropriate tasks, with a conceptual, relational and structural approach to the topics under study. This action is stimulated by the teaching work that develops an approach to knowledge from a structural vision, with the purpose of an active learning, with evaluation as a form of positive stimulation of that learning (Biggs, 2011; Biggs, 2014; Biggs and Collis, 2014).

From the perspective of students' deep learning, one of the proposals in the literature is the so-called aligned constructivism (Biggs, 2014) that mixes a constructivist approach—with the idea that the apprentice builds his knowledge from the interpretations he develops from his pre-existing schemes—and alignment—as a principle of curriculum theory that states that assessment tasks are aligned with what is intended to be learned—. In this proposal, the expected results specify the activity that the student must develop if he or she wishes to achieve the desired result together with the content to which that activity refers, how it should be learned and under what standard it will be evaluated. The underlying idea is that if the student knows how he or she will be evaluated and with what quality he or she is expected to develop that activity, the students will tend to reach that level, which can be profound, depending on the teacher's perspectives (Biggs, 2011). An idea similar to that of aligned constructivism, although with variations in how to conceive of evaluation as a tool to test learning rather than as part of the teaching and learning process, is the backward design (Wiggins et al., 2005). Here, the first step of the design is the identification of the desired results, followed by the determination of acceptable evidence (evaluation) to finish with the learning and instructional experiences. As we can see, in both cases, the learning results and the evaluation are the key points of the instructional design on which the other instances of planning are articulated.

A different conceptualization of the instructional design process is that in which the contents are fundamental when designing the teaching and learning process. From this perspective, for example, concept-based curriculum design (Stern et al., 2017) tells us that abstraction at the conceptual level is fundamental to understanding problems and creating solutions. That is, independent facts do not allow a proper transfer to other contexts. In this sense, traditional curriculum models based on content coverage rarely produce deep and transferable learning (Stern et al., 2017; Burch et al., 2015). And this is even more dramatic when we focus on the area of engineering, especially communication technologies, where the rate of technological change is extremely high. In this context, it is necessary to promote formative processes that allow the development of synergistic thinking where there is a cognitive interrelation between low and conceptual levels according to the needs of individuals. Therefore, it is essential to establish the contents to be taught, but from a structuring of knowledge based on concepts and their relationships, not simply as lists of topics to be addressed. From this same perspective, the determination of threshold concepts (Meyer and Land, 2006; Burch et al., 2015)—defined as those concepts that allow students to open their thinking to a new and broader form of understanding of some topic, which could not be accessible without their study—together with the identification of those troublesome concepts—concepts of wide complexity for students due to their level of abstraction or their requirements of mastery of previous knowledge— are fundamental to the time of establish such a conceptual structure to enable the approach, deep understanding and subsequent transfer to new contexts.

In general, our view is that, in instructional design, learning outcomes and assessment processes along with the knowledge structure based on threshold concepts are central to pursuing deep learning, allowing the harmonisation of all elements of the teaching and learning process. However, it is necessary to change the vision of teaching as an individual action of teachers towards a new structure of design, planning and execution of a collaborative teaching, supported by the formation of academic cloisters. In the next section, we present a first proposal that allows us to approach this type of collaborative design.

3 TOWARDS A COLLABORATIVE INSTRUCTIONAL DESIGN FOCUSED on CONCEPTUAL STRUCTURE AND LEARNING OUTCOMES

As mentioned in the preceding sections, this proposal is based on a principle of collaborative teaching, supported by teacher cloisters. Figure 1 shows the different stages of the teaching and learning process, and interrelations that are generated between the teachers of the cloister. The design phase corresponds to the instructional design of the subject, which is an activity that is executed among the teachers belonging to the domain in which this subject is inserted. That is, this whole process is not developed individually by the teacher who dictates this subject, but he coordinates a working group that is responsible for the entire design process, which includes the structuring of contents, the desired learning standards, the evaluation tools and the experiences and learning resources needed to achieve the desired results. In a second phase, the proposed design is put into effect; this activity is individual (or group, according to the teaching modality of the university) and is implemented by the professor in charge of the subject and/or his collaborators. A third stage, which develops as the proposal is implemented, corresponds to the control and feedback stage. In it, again, the teacher cloister, specifically the teachers of the corresponding domain, analyze the preliminary and/or final data, as appropriate, of the evaluation and assessment processes designed, in order to take the necessary corrective measures during implementation and to improve the initial design.

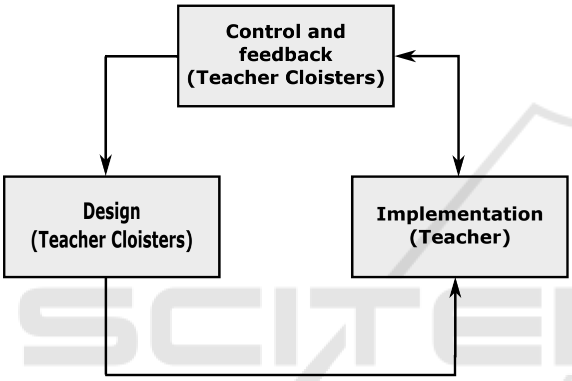

Figure 1: Phases of the teaching and learning process, and its relationship with the teacher cloisters.

With respect to instructional design it rests on a fully interactive multilayer architecture, which implies a cross-layer structure, so that the information provided from the various layers can be used by the others in the design process. Conceptually, this architecture has five layers or levels (see Figure 2) that will be described in the following subsections.

Level of Conceptual Structure

This level of the instructional design process will identify the different threshold concepts and problem concepts associated with the topic of study, as well as the relationships that are generated between them and with the previous knowledge that students must possess to be able to face them. The expected result is the conceptual structure of the knowledge that will be addressed throughout the course, and prioritizing a structure based on threshold concepts. For the development of this level is expected the joint work of the teachers of the domain, experts in these topics, and, if possible, the participation of students who have studied this subject, to detect the problematic concepts and their motivations.

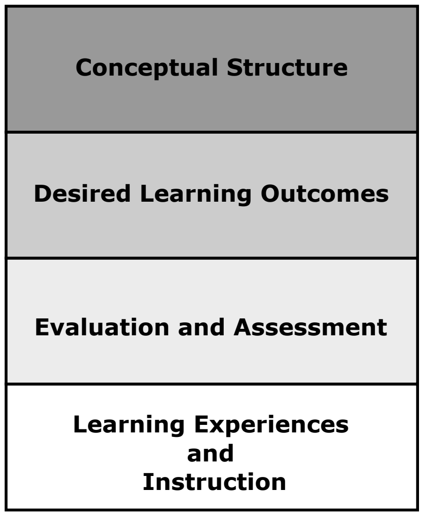

Figure 2: Architecture of the instructional design process focused on a conceptual structure and learning outcomes.

Level of Desired Learning Outcomes

Following the proposal of (Biggs and Collis, 2014), at this level, our intention is that both teachers and students be aware of the different levels of understanding required in the course, for each of the aspects studied. To this end, at this level, the teaching team will propose the desired learning results, which must be achieved after the teaching process and must clearly specify what to do and under what standards the student will demonstrate these achievements.

Level of Evaluation and Assessment

At this point, following the perspective of the backward design proposed by (Wiggins et al., 2005), it is necessary to determine how we will recognize that the student has achieved the desired result? That is, at this level, teachers will design assessment and evaluation activities and instruments that will allow feedback on the student's learning process and the teacher's teaching process and also, generate the corresponding scores for your accreditation. The design perspective that is prioritized is that the evaluation activities are part of the teaching process and therefore must be structured so that the student can deepen his learning from them, more than obtain a score and the accreditation of the achievement of the desired results.

Level of Learning and Instructional Experiences

Finally, with all the information obtained at the previous levels, it corresponds to this point the design of different learning experiences and instruction so that students reach the desired levels of understanding. At this level of design, according to the proposed degrees of comprehension, the established knowledge structure, the area of knowledge and the evaluation instruments developed, teachers will establish methodologies, activities and teaching resources needed to systematically provide students with experiences that enable them to achieve the desired level of performance.

As can be seen, this instructional design proposal is based on the conceptual structure of knowledge and evaluation as essential aspects in the harmonization of the teaching and learning process, for the achievement of deep learning in university students.

4 CONCLUSIONS

In this article we have presented the conceptual description of a proposal of instructional design at university level that, unlike other proposals present in the literature, is based on the collaborative action of teachers belonging to a domain of knowledge within a teacher cloister. To this end, the conceptual structure of knowledge to be taught is defined as central and harmonizing aspects of the teaching and learning process (threshold and troublesome concepts) and the clear definition of the desired learning outcomes together with the tools for assessing and evaluating those outcomes. Our intention is to test this proposal through the Teacher Cloisters of Telecommunications of the Salesian Polytechnic University of Ecuador, in the area of mobile and wireless communications, in the Career of Telecommunications Engineering.

REFERENCES

Beamish, R. (2016). *The Promise of Sociology: Classical Approaches to Contemporary Society*. University of Toronto Press.

Biggs, J. (2014). Constructive alignment. *HERDSA Review of Higher Education*, 1:25.

Biggs, J. B. (2011). *Teaching for quality learning at university: What the student does*. McGraw-hill education (UK).

Biggs, J. B. and Collis, K. F. (2014). *Evaluating the quality of learning: The SOLO taxonomy (Structure of the Observed Learning Outcome)*. Academic Press.

Bongiorno, G., Rizzo, D., and Vaia, G. (2018). Cios and the digital transformation: a new leadership role. In *CIOs and the digital transformation*, pages 1–9. Springer.

Brown, J., Gosling, T., Sethi, B., Sheppard, B., Stubbings, C., Sviokla, J., and Zarubina, D. (2017). Workforce of the future: The competing forces shaping 2030. *London: PWC*.

Burch, G. F., Burch, J. J., Bradley, T. P., and Heller, N. A. (2015). Identifying and overcoming threshold concepts and conceptions: Introducing a conception-focused curriculum to course design. *Journal of Management Education*, 39(4):476–496.

Elrod, S. and Kezar, A. (2017). Increasing student success in stem: Summary of a guide to systemic institutional change. *Change: The Magazine of Higher Learning*, 49(4):26–34.

Finelli, C. J. and Froyd, J. E. (2019). Improving student learning in undergraduate engineering education by improving teaching and assessment. *Advances in Engineering Education*.

Graham, R. (2018). The global state of the art in engineering education. *Massachusetts Institute of Technology (MIT) Report, Massachusetts, USA*.

Irons, A. (2007). *Enhancing learning through formative assessment and feedback*. Routledge.

Karpicke, J. D. (2017). Retrieval-based learning: A decade of progress. *Grantee Submission*.

Kaynak, O. and Sait, S. M. (2020). Engineering education at the age of digital transformation.

Limniou, M. and Smith, M. (2014). The role of feedback in e-assessments for engineering education. *Education and Information Technologies*, 19(1):209–225.

McConlogue, T. (2020). Assessment and feedback in higher education: A guide for teachers.

McTighe, J. and Wiggins, G. (2012). Understanding by design framework. *Alexandria, VA: Association for Supervision and Curriculum Development*.

Meyer, J. H. and Land, R. (2006). Threshold concepts and troublesome knowledge: An introduction. In *Overcoming barriers to student understanding*, pages 27–42. Routledge.

Moore, K., Frazier, R. S., et al. (2017). Engineering education for generation z. *American Journal of Engineering Education (AJEE)*, 8(2):111–126.

North, K., Maier, R., and Haas, O. (2018). Value creation in the digitally enabled knowledge economy. In *Knowledge Management in Digital Change*, pages 1–29. Springer.

Qadir, J., Taha, A.-E. M., Yau, K.-L. A., Ponciano, J., Hussain, S., Al-Fuqaha, A., and Imran, M. A. (2020). Leveraging the force of formative assessment & feedback for effective engineering education.

Rimbau, G., E. (2013). La dirección de persones en la sociedad del conocimiento. Technical report, Universidad Oberta de Cataluña.

Steiner, O. (2020). Social work in the digital era: Theoretical, ethical and practical considerations. *The British Journal of Social Work*.

Stern, J., Ferraro, K., and Mohnkern, J. (2017). *Tools for teaching conceptual understanding, secondary: Designing lessons and assessments for deep learning*. Corwin Press.

Umbach, P. D. (2007). *Faculty Cultures and College Teaching*, pages 263–317. Springer Netherlands, Dordrecht.

Wiggins, G. P., Wiggins, G., and McTighe, J. (2005). *Understanding by design*. Ascd.