THE PEDAGOGICAL POTENTIAL OF THE FACE-IT PORTAL: LEARNING FROM THE EXPERIENCES OF FACULTY AND STUDENTS

Marica Liotino[1]
Monica Fedeli [2]

ABSTRACT: The paper discusses the integration of technology in education, particularly in the context of engineering universities. It emphasizes the need for technology that aligns with pedagogical intentions and addresses the challenges faced by professors. The research is conducted in the context of a wider project, Face-it, which aims to develop a portal that supports teaching and learning by facilitating a graphical representation of course content, providing resources, and collecting feedback on learning. The research adopts an action research approach to investigate the portal's development and implementation in engineering courses. In the first phase, a standardized language between developers and users has been established by creating guidelines for describing course content and learning outcomes. Also, a new taxonomy is being developed to categorize skills and index teaching-learning resources; validating the taxonomy is part of the study as well. In the second phase, the study involves exploring the pedagogical affordance of the portal through activity system reconstruction. Data is collected through interviews and a survey with professors in the first phase, and through interviews with developers and professors, as well as surveys with students, in the second phase. The study's results aim to contribute to the existing literature on technology-enhanced learning in engineering education and guide future research directions for the Face-it project.

Keywords: engineering higher education, technology-enhanced learning, action research, taxonomy validation, educational technology, engineering, Face-it

Although several technological tools have been created to support the presentation and dissemination of content and the development of knowledge (such as computer-assisted instruction and massive open online courses), to support the management of curricula, instruction, and learners (i.e., learning management systems), or to provide immediate and personalized instruction or feedback (such as intelligent tutoring systems) varied are the problems still encountered by those teaching.

Among the most frequently encountered difficulties in undergraduate engineering teaching are the creation and presentation of adequate teaching materials, the creation of tools for assessment and evaluation of a wide range of skills from the simplest to the most complex, the actualization and application in the practical life of theoretical concepts, and the active involvement of the learner (Ouhbi & Pombo 2020, Zenger, 2018). Teachers also report as problematic for learners the understanding of existing connections between topics, which are often fragmented for reasons of curriculum design across different courses within university programs (Knorn et al 2019). Along with the use of specific teaching methods and techniques, the use of technological tools appears to be supportive in solving the problems listed above, but finding technologies appropriate to the intent and pedagogical needs of those teaching and the content they teach also appears to be problematic (Ouhbi & Pombo 2020). Moreover, factors related to the design of technology-supported learning environments, how technology is used to foster teaching and learning, and the effects generated by its use in engineering learning contexts at the

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[1] University of Padua, marica.liotino@phd.unipd.it
[2] University of Padua, monica.fedeli@unipd.it

undergraduate level remain largely unexplored (Gottlieb et al.,2019). Indeed, over time, faculty members have developed technologies that are shoehorned into their teaching contexts, that could support their teaching needs and facilitate learning such as systems for formative assessment and learning progress monitoring (Rodrigues & Oliveira, 2014), dynamic concept maps with interactive response systems (Wang et al., 2008; Sun & Chen, 2016).

In the same vein, the Erasmus+ project group "Face It: Fostering Awareness on Program Contents in Higher Education using IT tools" is working on a portal for mapping program contents integrated with a database of exercises for learner self-assessment that responds to the needs of undergraduate engineering education. The effort here is to create a tool that responds to the needs of an educational community, triggering a shared process of developing the tool that is constantly informed by the research data itself. Not surprisingly, Face-it brings together engineers and pedagogies from different universities (Uppsala University, Université Libre de Bruxelles, Norwegian University of Science and Technology, University of Padua) to develop new shared methods for defining, collecting, managing, processing, and visualizing university program content in association with program learning objectives (PLOs), teaching-learning activities (TLAs), and intended learning outcomes (ILOs). The goal is to make the teaching-learning process visible by improving a common understanding of what is being taught, what is expected of those who are learning, and how teaching/learning is linked within a program. In addition, we aim to develop tools that in addition to visualizing expected learning can detect the status of learning, to provide data to the learning subjects themselves and to faculties to make informed choices. At the same time, the project aims to create common practices, requiring the interaction and collaboration of a variety of professionals committed to improving their competence through interaction and mutual support, generating true communities of practice (Lave, & Wenger, 1991; Wenger et al., 2002).

The study began by defining a shared process of content description by decomposing the teaching-learning process into a set of proximal outcomes expressed in terms of skills. In the second step, a categorization system for these skills was defined (the process of identifying the classification system and defining content will be explained in more detail in the methodology paragraph). In parallel, the portal for the graphical representation of teaching content and collection of teaching and assessment materials was developed. Initial initiatives to use the portal were then investigated, to explore the pedagogical potential of using such a tool when embedded in teaching-learning processes and to improve the functions of the portal itself. The pedagogical research work takes shape in this context, and the next section will add more information regarding its goals and theoretical approaches.

The Theoretical Framework

According to the definition given by the UNESCO International Bureau of Education (2016) when we talk about Technology Enhanced Learning (TEL), we mean the use of information and communication technologies (ICT) as tools to support student learning, including assessment, tutoring, and instruction. It encompasses various applications such as web-based and computer-based learning, virtual classrooms, and digital collaboration. Content is delivered through electronic media, providing learners with access to new ideas for reflection and integration into their existing knowledge. Among different media, computers facilitate collaborative learning, encouraging teamwork and shared meaning, and social media/software applications like blogs and wikis enable communication, knowledge access, content creation, and online collaboration. So, when integrated into curriculum design, technology can enhance teaching practices and learning experiences. Other words used as synonyms are e-learning or digital learning, which utilizes technology to improve educational processes (UNESCO, 2016).

Educational Technology dwells on the pedagogical function of technology and, therefore, the investigation and development of methodologies and approaches to education using technology and the in-depth study of technological tools as a means to foster learning (Bonaiuti, et al., 2017). In an educational context, pedagogical affordances or educational features mean the potential support an ICT tool provides to achieve predetermined learning goals and include pedagogical approaches and learning activities (Analysis of Affordance, 2016). They are also defined as "those characteristics of an artifact that determine if and how a particular learning behavior could possibly be enacted within a given context" (Kirschner et al., 2004, p 51). For example, some affordances already identified in environments employing ICTs support science learning through four main effects: promotion of cognitive acceleration, provision of a wider range of experiences so that learners can relate science to their own and real-world experiences, increased learner self-management, and facilitation of data collection and presentation (Webb, 2005).

According to experts, a key step in the process of implementing TEL is to make room for reflection on users' needs, that is why initiatives that encourage the co-construction of such contexts seem to be more successful (Laurillard et al., 2009). Indeed, the incorporation of partially finished artifacts within a community allows them to be adapted to the interests and needs of the community, the artifact thus becoming the result of a process of participation and negotiation between those who develop it and those who use it (Laurillard et al., 2009). As Wenger (1999) confirms, when a new artifact is introduced into a group, it must go through a process of meaning-making before it can be used and introduced into practice. Also, according to Laurillard and colleagues (2009), holistic and systemic approaches should be favored in the adoption and implementation of TEL. There are also other aspects to consider according to the same authors. First, it is important to understand the professional context where the technology is implemented as this will also determine the curriculum, pedagogical choices, and assessment processes. Second, it is significant to make sure that there is consistency between the values of those who teach, and the innovation introduced and that faculties have time to reflect on their beliefs about learning and teaching because TEL requires a more structured and analytical approach to pedagogy. Third, it is important to promote co-development of TEL products and environments to create a sense of ownership through mutual involvement, it would also be optimal if the relationship of interdependence between those conducting the research and the user is highlighted in the research conducted. Fourth, to make the best use of technology, it appears necessary to accompany faculties in breaking with institutional models of teaching and learning in favor of radical change. Finally, it is essential that those who teach collaborate in the design of teaching or activities that use technology (Laurillard et al., 2009, p 304).

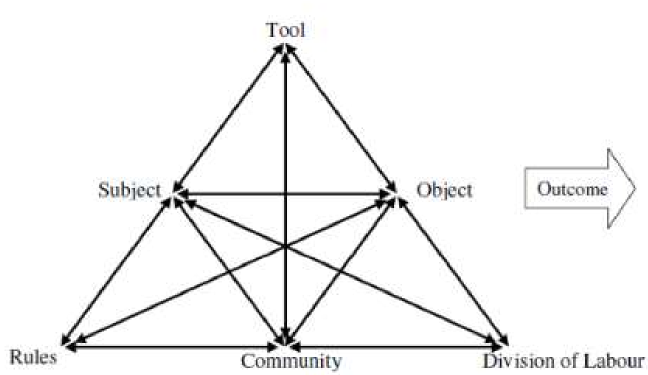
A sociocultural approach characterizes this study in line with what has just been reported and the author's ideas. Indeed, in sociocultural thinking "artifacts are at the center of human learning and knowing," and their mediating function is a central element (Sutherland et al., 2009, p. 41). However, ICT tools alone do not create better teaching or learning, rather the inclusion of new ICT tools in an educational context is part of an overall process of redesigning and redefining content and methods (Sutherland et al., 2009).

The integration of different theoretical frameworks underlies this study; in fact, the use of the framework of pedagogical practices related to ICT use (Webb & Cox, 2004) along with activity theory (Engeström, 1987) provides a sufficiently rich lens for interpreting the processes of integration and portal use. Activity theory (Engeström, 1987) helps us analyze the process of implementing the Face-it portal in engineering classrooms, capturing the complexity of educational contexts. In line with what has been said so far, activity theory sees the integration of technologies as tools that mediate social action. Specifically, an artifact "to become a tool is to become part of someone's activity" (Christiansen, 1996, p. 177).

As shown in Figure 1, in addition to the subjects and instrument considered, the activity system also includes the object, that represents the goals, motivations, and purposes for which one engages in activities; the rules, that is, the mediating elements such as regulations, cultural norms, and practices of the people involved in the activities; the community, understood as the physical and conceptual environment where the activity takes place; and finally, the division of labor, thus variations in roles and responsibilities (Mwanza-Simwami, 2011).

Figure 1

Activity system



Source: Engeström, 2001

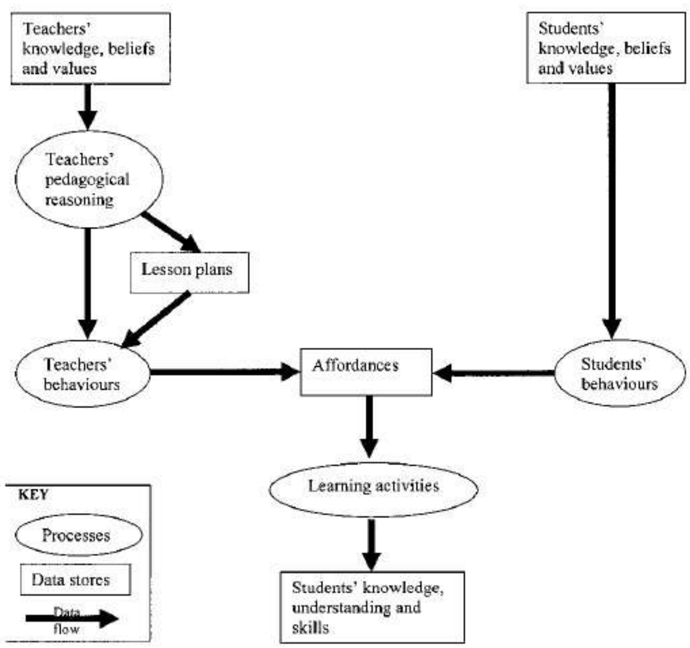
Such a framework also supports us in identifying contradictions within and between activity systems and the subsequent refinement of the instrument and its implementation processes (Ekundayo et al., 2012).

On the other hand, the framework for pedagogical practices related to the use of ICT proposed by Webb & Cox (2004) emphasizes the need to examine the values and beliefs of ideas along with pedagogical reasoning to identify ICT-related pedagogical approaches of those who teach. In this way, their practices of using ICT tools can be understood (Figure 2).

By pedagogical reasoning, the authors refer to Shulman's model of pedagogical reasoning and action (Shulman, 1987), a useful framework for exploring how decisions about teaching-learning processes are made (Starkey, 2010).

Figure 2

Framework for pedagogical practices relating to ICT use.



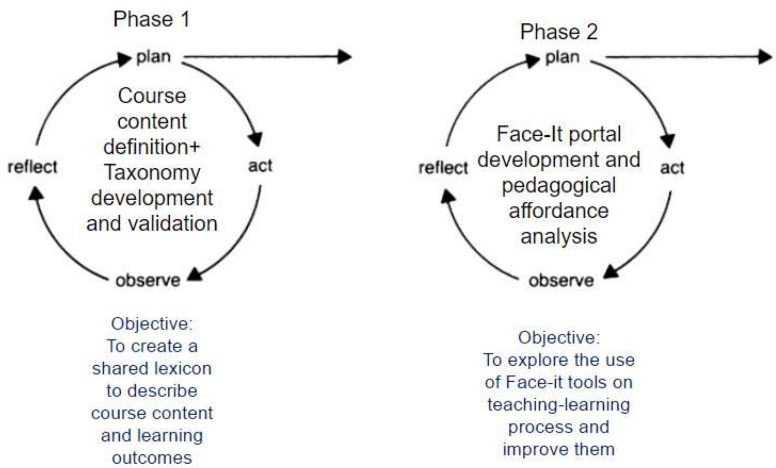
Source: Webb & Cox, 2004, p. 239

Methodology

The research work is articulated through action research, where the researcher and academic staff are co-participants (Trinchero, 2002; McNiff & Whitehead, 2009). The cornerstone of the research process is the action-reflection spiral, characterized specifically by two main phases (Figure 3). The first phase was devoted to determining a shared language useful for describing teaching content and defining its sequencing. The second phase, following the fine-tuning of the portal also based on previous contributions, was devoted to deepening the pedagogical potential of the same and to the study of the first experiences of its use by faculties, students, and undergraduates in different university engineering courses.

Figure 3

Research process.



Source: Elaborated from McNiff & Whitehead, 2002, p.41

The following paragraphs will go on to briefly explain the references and actions taken in the two phases.

The Description and Categorization of Teaching Content

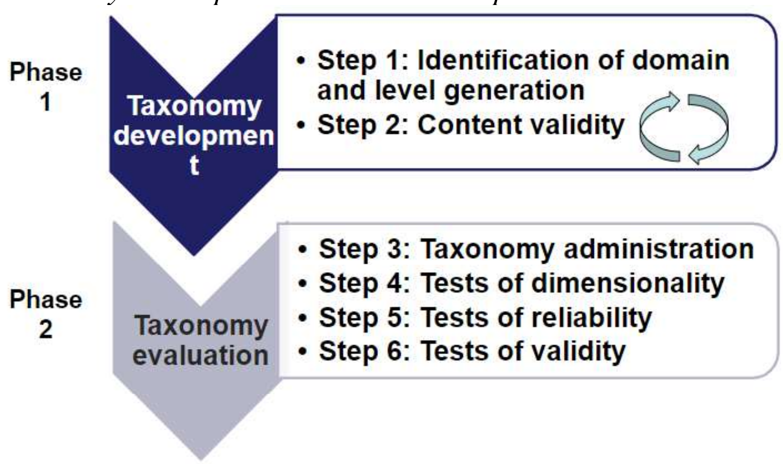
To ensure the use of a standard, shared language among the different project members and for all portal users, guides were generated about how to describe teaching content and expected learning. The literature search turned primary attention to curriculum development studies of the 1950s and 1960s, primarily focused on identifying educational goals and translating them into curricula. Related is constructive alignment, an approach to curriculum design that seeks to optimize the conditions for quality learning and create a coherent learning environment that aligns teaching methods and assessment practices with teaching objectives (McMahon & Thakore, 2006). It uses ILO definitions to describe what students should know and be able to do by the end of the course; a definition of TLAs to help students achieve the ILO; and an identification of assessment criteria and methods (Biggs, 2003). The curriculum design and development movements, focusing on sequential structuring and learning assessment, introduced taxonomies into educational contexts. Typically, they stem from behaviorist models of task analysis (analysis of the basic requirements for performing a task) and the construction of learning process feedback systems originated from the cognitivist framework (Bonaiuti et al., 2017). Bloom et al. (1956) first introduced the concept of the taxonomy of educational objectives intending to reduce the ambiguity of educational activities and sequentially organize the assessment process. The goal was to identify expected behaviors and the skills required for their achievement.

Such a tool married our needs to categorize the skills expected and possessed and to index the teaching resources in the portal. A review of the literature on engineering higher education challenged the use of existing educational taxonomies, prompting our choice to create one from scratch, inspired by existing taxonomies, but one that would best fit the needs of the academic community in question and the project. The scholarly literature did not suggest a satisfactory and validated process of taxonomy development and validation; therefore, the processes previously followed by other scholars to validate their taxonomies were studied. The process to be followed was based on taxonomy development and validation process reported by other scholars (Šmite et al., 2014; Zamanzadeh et al., 2014; Creswell, & Clark, 2007) and scale validation processes (Boateng et al., 2018) as a reference. In detail, a "conceptual-to-empirical" taxonomy/rubric development type was followed (Nickerson et al, 2017) following a deductive method, where typologies were derived qualitatively, but subsequently were evaluated quantitatively for their goodness of fit to collected data (Bailey, 1994).

As can be seen in Figure 4, the process consists of two main steps and six steps.

Figure 4

Taxonomy development and validation process



Source: Authors' creation

First, following a study of the literature, we identified the domain and generated the levels, creating a draft of the taxonomy. The new taxonomy emphasizes the difference between cognitive and practical skills and consists of two main dimensions USE and EXPLAIN. Each domain describes four levels of skill complexity.

We then evaluated the content validity of this draft taxonomy. According to Boateng et al. (2018), the assessment of content validity is best done through a combination of external expert judges and judges from the target population; therefore, ten faculties and subject matter experts were recruited through email (9 male, one female). They belonged to the professional network of the face-it educational community and were not involved in writing the taxonomy. Ten meetings (one for each participant) were organized using a video call platform. All meetings were conducted in the same way: participants were asked to read the manual created to explain how to use the taxonomy. Then, they evaluated the taxonomy level of a series of 15 exercises. Each meeting ended with a semi-structured interview.

Based on the feedback collected the taxonomy was modified, and a rubric was also constructed to facilitate its use by professors and students. In addition, based on the interviews, a survey was created to test the taxonomy with a larger number of people. Content validity testing was performed a second time, recruiting new professors, and introducing testing by some students as well (five engineering professors, two pedagogy professors, and three students). This time the data collection was carried out through the survey, which was performed in my presence and contextually tested. The survey guided participants in discovering the taxonomy, applying it through 15 exercises, and collecting data on taxonomy validity. According to the new information gained during the second validity check both the taxonomy and the survey have been modified. At this time, the second phase of the taxonomy development and evaluation process has been undertaken and the survey has been sent via email to a statistically relevant sample. National and International members of the control systems engineering community have been involved in this phase.

The Pedagogical Potential of the Face-it Portal

Following the Educational Technology perspective and what is already mentioned in the theoretical framework, in the second cycle, the study sought to understand how the portal, in its current version, can support faculties in achieving their educational goals and those who are learning. Therefore, the goal is to measure the pedagogical potential/affordance of the tool designed and developed by the Face-it group to understand how it can be used to support teaching-learning processes. Specifically, this phase of the study analyzes the actual and perceived pedagogical aspects of the Face-it portal. The actual (or designed) affordances "are the full set of designed features or functions that the artifact can provide for its users to perform certain tasks. [...] Comparatively, the perceived affordances often refer to those features that are known to or often used by the user" (Wang et al., 2010, pp. 70-71).

Therefore, the developers' presentation of the portal's features is accompanied by the exploration of the opinion of engineering faculty who have employed the tool in their teaching. The study aims to analyze the processes of development and implementation of the Face-it portal, and the pedagogical opportunities offered by the integration of the tool in terms of improving teaching through the study of the first experiences of use in different contexts, delving into the complexity of each experience and giving voice to the different actors involved in the various contexts. So, at this stage, the research seeks to elucidate the decisions made by faculties when they opted to use the portal, how the portal was integrated into instructional design, the achievement of the goals it aimed to support, and why these choices were made. It also aims to explore how the implementation took place in teaching and learning processes and what the results were by listening to the voices of all members of the system.

Two cycles of semi-structured interviews with professors/developers and a survey of the students will help us to reconstruct the activity systems where the portal has been used.

Findings

Considering that the survey for the validation of the taxonomy is still active, as well as the conduct of faculty/developer interviews and the survey of students, who used the portal, only some partial data related to the taxonomy development and evaluation process will be presented here.

In the test of taxonomy content validity, five main categories are explored:

- Clarity, especially in terms of vocabulary, structure, and purpose, to see if the taxonomy is well and clearly described (Boateng et al., 2018; Mountrouidou et al., 2019; Wolever et al., 2020).
- Exhaustiveness, meaning integrity, i.e., compile all the dimensions and categories needed to practice difficulty classification (Huff et al., 1984; Mountrouidou et al., 2019; Tett et al., 2000).
- Effectiveness, i.e., whether the set goals were achieved, in this case, the difficulty of the exercise is graded and scored accordingly (Alvino et al., 2006; Bezzi, 2007; Pozzoli & Manetti, 2011).
- Relevance i.e., the usefulness to catalog the difficulty of exercises and to assess teaching-learning processes (Boateng et al., 2018; DeVon, 2007; Huff et al., 1984; Valentijn et al., 2015; Wolever et al., 2020).
- Distinctness between levels, i.e., whether the categories are confined, and each category is decoupled from the others (Spangler & Kreulen, 2002; Huff et al., 1984; Mountrouidou et al., 2019).

In the first test (with ten faculties and subject matter experts) the clarity of the taxonomy was generally understood, although some participants found the structure and lexicon less clear, with a few identifying critical issues in the wording. The explaining dimension was deemed less intuitive than the using dimension, possibly due to a lack of distinctness between levels. Participants felt uncertain about labeling choices during assessment compilation, indicating a need for clearer differentiation and additional examples in the manual. In terms of efficacy, all participants recognized the usefulness of the taxonomy for labeling exercises, although two expressed doubts about objectivity. The taxonomy was considered incomplete, lacking dimensions such as time and complexity. However, participants found the taxonomy relevant for teaching, as it helped align expectations, facilitate communication, and share materials within the community. For more details about the first version of the taxonomy and the first content validity test see Liotino et al., (2021).

Based on the feedback collected, the taxonomy was revised, and a rubric was created, i.e., "an assessment tool that explicitly lists the criteria for student work and articulates the levels of quality for each criterion", as well as the scoring strategy used to judge the performance/process (Ragupathi & Lee, 2020, pp.73-74). In this rubric the levels of quality are identified following the new taxonomy implemented, to operationalize and facilitate the use of the taxonomy in teaching-learning processes.

We now consider what emerged from the second test (in which other seven faculty and three students were involved). Although the clarity of the vocabulary and structure of the second version of the taxonomy appeared to have improved over the previous version, participants still experienced some difficulties during the labeling exercises. The main reasons identified for these difficulties related to the clarity of the exercises used (those to be labeled) and a still unclear difference between the E2 and E3 levels. In addition, the second version of the taxonomy would still be missing dimensions related to metacognition, and categories related to real-life scenarios/problems. Nevertheless, most participants indicated the taxonomy as effective for the classification of assessment resources and the assessment process, some, however, expressed doubts about the real existence of a level 0 (in which only computational and not comprehension/explanation skills are required or vice versa depending on the dimension being considered, whether Using or Explaining respectively).

Based on what emerged in this second step the rubric and the taxonomy were further edited and translated into English by two professional translators who first identified their translation and finally delivered an agreed translation. The survey for the validation of the taxonomy was also modified under the results of this phase. One substantial change involved modifying, replacing, and removing some exercises used in the labeling phase, as their lack of clarity was found to compromise the taxonomy test.

Conclusions

In response to the difficulties expressed by engineering faculties in the scientific literature, in line with the European Commission's initiatives to digitize higher education and hinged on the work of the Face-it project, this research aims to promote a participatory process for defining a description of teaching-learning content that can be functional for the Face-it portal. At the same time the study seeks the exploration of the processes of choice, development, and implementation of the portal in teaching and learning activities and to understand the impact of such choice in teaching-learning processes.

The objectives defined the first two phases of the research. Although the data collection of the first and second phases has not yet been completed, it is possible to dwell on the results of the first steps of the first phase. These steps saw us engaged in defining the description of teaching-learning content through the study of literature and the production of guides. Subsequently, the use of a new taxonomy was identified as suitable for the classification of the intended learning outcome. The content validity of the first draft of the taxonomy (developed from existing taxonomies in the literature) was tested by ten subject matter experts who were then interviewed. The clarity of the taxonomy and the exercises used to use it prompted us to develop a second version and modify the tools provided to guide its use (manual and exercises). The second version was also tested in terms of content validity by asking five faculties and three students to answer a questionnaire. Although the taxonomy was clearer, difficulties remained in distinguishing the levels within one dimension. The exercises (used as objects for the application of the taxonomy) also compromised the test of the taxonomy because they were poorly understood. These problems were overcome by modifying the survey and creating a third version of the taxonomy.

The results analyzed so far were informative for the progress of the face-it project. They have also highlighted a gap in the literature concerning the development and validation processes of taxonomies in the educational field, providing a contribution to reflection on this topic. The data being collected will contribute not only to the definition of the future research lines of the Face-it project but also to the literature on the use of TEL in engineering higher education, in the hope of promoting more informed processes in the choice and adoption of technologies for teaching.

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