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Content, language and intercultural challenges in engineering education: (E-)strategies to improve instructional design

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Abstract

Intercultural, multilingual and culturally and academically diverse classrooms are a common reality in current higher education (HE) landscapes, as globalisation is effectively taking place in all major schools. Rethinking instructional design strategies that contribute to the overcoming of communication and cultural differences in both online and blended learning processes may help not only improve the development of more efficient online learning environments but also meet the challenges of current teaching and learning processes. Special focus will be put into engineering education through the medium of English and the training of engineering lecturers in HE through communities of practice (CoPs), which present, integrate and discuss how to integrate content and language (through what is known as the content and language integrated learning (CLIL) approach) as well as trends, challenges and opportunities related to recent technological developments on students' learning outcomes. The description of the pedagogical training shared through a CoP describes E-strategies to improve instructional design in engineering courses in online learning environments when English is used as a medium of instruction and integrated with content in a CLIL approach.

Keywords: Higher education, CLIL/ICLHE, English Lingua Franca, instructional E-design, online learning environments, training of engineering teachers.

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1. Introduction

Nowadays, higher education (HE) research in engineering focuses on a wide variety of fields (Knight, 2011) from engineering thinking and knowledge to engineering learning mechanisms, systems and assessment. No matter in which perspective such research may take place, the final goals are driven to increase the knowledge and skills of not only the current but also the forthcoming generations of engineers, who will be working in global markets and through integrated web-based systems. These academic cultures of and for learning to work in the engineering fields are now becoming more dependent on the uses of English (foreign language and/or lingua franca) and on participatory methodologies for learning and articulating learning, which require student involvement with other students, teachers and prospective employers in order to develop international common projects or communicate across geographical distance with online technologies (Lewis & O'Dowd, 2016).

Online learning environments incorporate digital tools and resources to support the learning process. One of these processes is known as E-learning, which offers students cumulatively online delivery of information, communication, education and training (Chang, 2015). Blended learning combines both in-class face-to-face learning methods with E-learning contents and processes. Based on the proportion of content that is derived online, Allen and Seaman (2016) classify as blended instruction when 30–80% of the content is delivered online. According to the same authors, a course can be classified as traditional when absolutely no web-based content is delivered, and web-facilitated when online content is used, but is lower than that of blended courses. Online courses are considered as such when web-based content is higher than 80%.

However, such classification seems to be insubstantial, as teaching and learning depends mainly on the process rather than on the materials, or the way they are conveyed. When using online learning environments, it is generally accepted that blended learning has been preferred to conventional E-learning, since the former combines advantages of face-to-face feedback with the tools and advantages associated to digital virtual environments, namely, flexibility, easy access by the learner and the possible integration of sophisticated technological and multimedia resources explore virtual learning spaces. On the other hand, face-to-face learning, and the interaction between student and teacher and among students is known to enhance the learning and teaching processes. So, the challenge of web-facilitated teacher–student learning stands in simulating these kinds of supportive interactions (wikis, customised tasks, personal learning networks, forums for discussion of tasks and social forums; Carloni, 2013), while taking advantage of the new virtual communication modes such as networking, one-to-one and one-to-many communication, hyperlinked knowledge, customised access to content, and so on

Considering that online learning environments are recent tools, when compared to traditional teaching and learning methodologies, the necessary redesign of learning spaces turns out to be unavoidable. Reorganised learning spaces enable learning based on smart rooms and objective-based learning, leading to dedicated instructional design and related E-strategies to develop new teaching and learning processes.

One recent technological teaching and learning development in HE is related to the bring-your-own-device (BYOD) movement. The spontaneous implementation of BYOD allows students to follow face-to-face classes with their laptops, tablets or smartphones, visualizing the contents presented by the teacher in real time. The BYOD movement is boosted by the increasing number of students and workers possessing portable devices and the consequent opportunity to create innovative blended learning and M-learning and to support students' know-how in campus. The increase in students' and teachers' motivation enables the creation and implementation of the flipped classroom methodology. Consequently, face-to-face classes are currently used mainly to support students autonomous work rather than the conventional focus on distributing content to students by lecturers. Teachers may create classroom discussions or convert the classroom into a place where students create, collaborate

and practice what they learn in the video classes (Brown, 2016; Gikas & Grant, 2013; Song & Kong, 2017; Viberg & Gronlund, 2013).

An especially demanding context is associated to science, technology and engineering (STE) education, as related domains often require laboratory exercises and tasks to provide effective skill acquisition and hands-on experience. ICT teaching and learning tools are difficult to use particularly when online distance learning is required, as either the physical laboratory has to be enabled for remote access or it needs to be replicated as a fully software-based virtual laboratory (Potkonjak et al., 2016). New emerging technologies are being developed to assist the latter solution, which may be successful in overcoming some of the potential difficulties associated to virtual laboratories such as the enhanced computer graphics generation, the practical use of augmented reality, computational dynamics or virtual worlds.

STE virtual laboratories are potentially promising tools, as they allow full interactive simulations in which students perform experiments and collect data associated to real-life physical processes. However, it is of general consensus that these tools are currently used by engineering students only in an initial step of their courses, as they need to be followed by more in-depth hands-on experience with real physical equipment and devices.

In non-experimental teaching and learning situations, ICT tools and resources are replacing conventional non-digital materials such as physical handbooks or notebooks (Santamarta et al., 2015). A previously unknown paradigm for all aspects of learning, like online access to universal knowledge as well as online learning systems and platforms, is now available to all those wishing to undergo formal or non-formal learning processes. Online resources have been successfully blended with classroom-based learning and with distance or virtual education models, which are all part of digital learning environments.

One particular aspect that emerges from these new digital learning spaces is that the current digitisation of engineering work processes associated to the mobility of people and goods at a planetary scale have been leading to the increased need of effective intercultural communication skills, competence and tools to be incorporated into E-instructional design. Considering that English is used as a lingua franca among the majority of engineering professionals, the use of this language, which for many teachers and students is a foreign one, is key to current and future engineering professionals in order to find employment in a globalised world. To this end, it is of considerable importance that the teacher (of Engineering) is able to guide learning in English and to function in multicultural web-based environments where just knowing how to use the language will not necessarily guarantee success in communication.

Furthermore, next-generation learning management systems need to train HE instructors not only to make the best use of emerging ICT tools but also to adapt to the students' mindset related to digital learning environments and collaborative approaches to E-instruction. Lecturers and students have to learn to use technology to their benefits, as the sole availability of these tools produces no outcomes. To guarantee their efficient use in educational contexts, ICT tools have not only to be directly related to the learning content of the subject at issue (Duta & Martinez-Rivera, 2015) but also to be relevant for the diverse learning styles and cultures for learning of several diverse communities. Furthermore, dedicated ITC learning tools should help comply with the learning competences envisaged for specific contexts and domains.

1.1. Purpose

Hence, the need to provide current HE students not only with technological and academic cultures of and for learning but also with the adequate linguistic competences (in English) to use a language for global communication as well as develop intercultural communication skills to understand how a lingua franca is modelled by the home cultures of speakers and how it will be understood in order to act in demanding current and future global environments. This means decentring students from

previous exclusively language-centred methods of learning English and exclusively classroom-based activities and promoting opportunities for authentic uses of English through, for examples, online virtual exchanges or telecollaboration (O'Dowd, 2005), but also through adaptation of materials and resources by engineering teachers according to pedagogical principles that expose learners to authentic uses of English, help them pay attention not only to engineering content but also to features of authentic uses of English in particular contexts, as well as providing learners with opportunities to use English to communicate technological and academic knowledge and use online (Tomlinson, 2014).

This paper presents and discusses a pedagogical model for the in-service training of HE engineering lecturers and lecturers from other disciplinary fields, who are faced with the challenges described above. The training demonstrates how to integrate specialised disciplinary content and language (English) through a content and language integrated learning (CLIL) approach, while also introducing trainees to instructional design frameworks that support the development of 21st-century skills and technology-oriented learning processes. The paper draws on the implementation of concrete CLIL modules with engineering students in a Portuguese HE polytechnic institute and the creation of CLIL communities of practice (CoPs) as a paradigm change to support distributed learning, empowerment of learning communities made up of students and teachers as well as online learning environments that support the internationalisation and growth strategy of Higher Education Institutions.

2. Context: HE in-service training as the creation of CLIL CoP

In order to move from more traditional classroom face-to-face approaches to effective online or web-based teaching and learning, it is our contention that teachers have to be made aware of the pedagogical implications of the new learning landscapes that were described above. Traditionally, engineering teachers hold no pedagogical qualification, and their views on English as a vehicular language in the classroom are rather limited. They expect students to understand and produce content in English effectively, and they have no strategies in place to support student acquisition and development of specialised vocabularies and structures or their communicative ability. Furthermore, their views on technology use for learning and in teaching show almost no pedagogical concerns as to learning processes or outcomes.

Thus, we will focus now on describing how engineering teachers were trained in CLIL to become aware of the need to include explicit supportive instruction in English through task sequences in English that also support and promote intercultural communicative competence development. The blended in-service training invited trainees to test the use of technology for teaching and learning and to shift their ways of thinking from trainees getting face-to-face and online instruction to a CoP learning to share resources and views. This CoP also involved HE lecturers across several faculties, which facilitated the understanding of learning environments as CoPs where diverse beliefs about (engineering or other disciplinary) content and language converge into accepted social fields of practice (Freebody, Maton & Martin, 2008). The implementation of a CoP requires a strong sense of shared responsibility on the part of all the participants as well as a culture of collaborative learning among all involved that may not be natural for some national contexts, as is the case described. This CoP is not only shaped by the interaction of all participants (English and engineering teachers, teachers and students, students and students) but by the interactions themselves, which create a rich environment of contributions, comparisons and contrasts. Communication is achieved through the reciprocal relationships of all participants and their academic CoP across time and space.

2.1. What is CLIL?

Content and language integrated approaches (currently referred to as CLIL or, in some HE contexts, Integrated Content and Language in Higher Education (ICLHE)) have been on the rise in HE in Europe to facilitate the proficient specialised and academic use of a foreign language that will enhance student employability and preparation to respond to a globalised world. CLIL is a relatively innovative

educational approach in European school education, which combines learning content with learning a foreign (or additional) language, focusing on learning both at the same time. The foreign language is acquired through subject-related contents provided in such a way to encourage learning. Special attention is paid to learning skills, as they are pivotal for an efficient linguistic and communicative learning. One further important aspect of the CLIL approach is that it impacts on the way students think and their cognitive skills, helping to broaden their conceptual mapping. In terms of teaching, CLIL exposes students to purposeful, innovative and meaningful (authentic) learning experiences, thus approximating students to life-like scenarios. CLIL further favours a topic-centred approach (Mehisto, Marsh & Frigols, 2008). CLIL approaches also cater for new ways of learning and thinking in more than one language as a valued 21st-century skill, on a par with a development of electronic literacy, such as videoconferencing, online interviews, email or chat rooms for live communication, integrated in content and language learning sequences, besides experiments with online virtual exchanges or telecollaboration.

2.2. Blended course: content and language

Any scientific or pedagogical successful online instruction needs to take into account the new paradigm of the language user in subject-specific fields of knowledge. These are highly contextualised CoPs, where it makes no sense to separate the content from the language to teach content. Form and meaning have to be negotiated together and knowledge is shaped in that complex interrelation (Moore & Dooly, 2010).

The competence needed by HE students and global workers may be defined as the knowledge, skills and attitudes that enable individuals to deal constructively with questions arising from cultural diversity (Dooly, 2006), in the sense of diverse protocols used to do things and learn about reality, despite using a common language (or a lingua franca such as English) for communication.

Thus, learning environments should be capable of including practices and methodological techniques that integrate content, language and intercultural competence development. Instructional design needs to create room for diverse students and teachers, with different values and frames of interpretation and reference; allow time for learners to get accustomed to it, that is, to effectively work and learn collaboratively; and understand how a foreign language can mediate content through opportunities for cross-cultural negotiation and learning that are personal and classroom or web based. One further aspect to take into consideration for instructional design is that English is not used for communication alone but to mediate knowledge, that is, for learning understood as a sociocultural knowledge construction and a student-centred constructivist concept: ‘Students need opportunities to construct their own understanding of subject community knowledge, using appropriate frames of reference and vocabulary under expert tutelage’ (Moate, 2010).

Furthermore, teachers and students who use English as a vehicular language for learning and work may feel ‘seriously limited in their ability to participate at a sufficiently high academic level’ (Wilkinson, 2013). This may not be solely due to their linguistic competence but relies heavily on the genre practices in a particular field. Thus, in order to support heterogeneity of context in relation to linguistic diversity, diverse instructional approaches have to be used, which are more suited to the students’ own norms and expectations, if they are to engage their participation in learning.

In terms of content through language, the blended course focused on the CLIL approach and on the characterisation of the learning environment as essentially cross-cultural and bilingual (in English and in the students’ mother tongues). Relevance was given to scaffolding techniques in learning and communicating knowledge in a foreign language; adapting or scaffolding online ready material and resources in English to suit particular specialised audiences; supporting student learning through linguistic monolingual, pictorial and multilingual glossaries of specialised vocabulary as well as multimedia resources; creating room for bilingual scientific terminology that gains space and/or loses domain between the language of instruction and the home language of the student; raising

intercultural awareness raising that imply the negotiation of established and new social practices of particular technological and professional contexts; and creating positive responses to linguistic and cultural diversity by openly negotiating common and different assumptions of teachers and students regarding formal structures of knowledge and common practices.

Through English and comparison, participants were made aware of preferred genres in their discipline, favoured interpretive frameworks and 'register combinations, ways of coordinating knowledge in language and image, ways of using abstraction and technicality' (Freebody et al., 2008). By integrating English and engineering, the course gave relevance to 'the shared linguistic repertoire available to the interlocutors in multilingual educational settings with their expertise in the respective content area and its genre-specific conventions' (Smit & Dafouz, 2012). It further emphasised English as a tool for communication and as integrated with the specialist content.

CLIL engineering tasks were designed to bridge all these aspects such as contrasting national to international norms and regulations, or building bilingual (sometimes visual) specialised glossaries to support student learning and also prevent domain loss in the students' own language or international collaborative tasks that involve discussion and negotiation of several aspects in order to reach completion of a project or resolution of a problem (telecollaboration).

2.3. Blended course: teaching approaches

HE teachers from several disciplines were invited to sit together through initially face-to-face and then blended training (classroom based and E-learning) sessions and learn about CLIL in order to design learning sequences for one or more teaching modules they would design, implement and monitor in class with students to collect evidence on their own and student satisfaction with the integrated approach of language and content learning (CLIL).

As familiar users of web-based tools for learning, such as a Moodle E-platform, engineering teachers showed no resistance to designing online instructional sequences for blended learning online and in the classroom. However, firstly, the training focused on how to work in tandem with the English teacher and, secondly, how to engage students in effective communicative uses of English as a Lingua Franca in meaningful scenarios while learning specific engineering contents.

Given the student-centred nature of CLIL, a shift in teaching approaches from top-down lectures to more interactive web-based teaching styles was expected to transform 'the main figure of knowledge-provider to that of facilitator in the learning process' (Dafouz-Milne & Sanchez Garcia, 2013), which it did. This became particularly evident in the Moodle-based CoPs and learning used that require students to cooperate and teachers to rethink their role as E-teachers in blended (or E-learning) models of teaching (De Santo & De Meo, 2016). This use of Moodle to share knowledge and practice yielded interesting realisations on highly contextualised academic cultures of learning, such as direct and indirect forms of student and teacher participation; negotiations needed to move from one set of practices linked to teaching in one language culture to another culture for learning (English); reorganisation of time needed to complete a task, revised it and discuss it with others; and so on

3. Lessons learnt from the implementation of CLIL modules with engineering students

The training of both engineering and English teachers, who were expected to collaborate, uncovered their own teaching conceptions and methodological skills, while inviting them to focus on their own students' needs, linguistic skills and motivation to learn in English. From the field notes they took through a 3-year implementation period of one or more CLIL modules, lessons can be shared for further development of the CLIL technology-enriched learning space promoted.

An adjustment was needed to all materials and resources used by HE teachers when they decided to teach through English and also when they decided to introduce online ready-made materials in English, given that their students will need support to learn through the additional language. If we take

into consideration that engineering students will have some knowledge of English but are unable to fully use it for academic learning and working, most multimedia materials and resources available online, need to be scaffolded for their learning needs, both linguistically and in terms of the content. Teaching through English entails differences that trainers need to be made aware of in terms of cultural and academic teaching style (Unterberger, 2012).

Just as good quality materials and resources available online need to be prepared to meet students' needs, classroom instruction language (in English as used by non-natives) is required to simplify, substitute, explain and expand on general instructions available online for a particular task. Oral discourse, for example, needs to be prepared through a pre-task that will prepare students for what they are learning, through a while-viewing task to focus learners' attention on particular issues she or he may encounter some difficulties with and through a post-task that will revise vocabulary, syntax and content.

Culturally, sensitive scaffolding also includes attention to diverse academic learning styles, such as a foregrounding of theory over practice or vice versa; a choice of lecture-type input that requires learners to listen and watch passively over step-by-step inquiries or questioning that require constant interactivity of the learner with the content, or vice versa; types of student participation; expectations of workload, and so on.

3.1. Challenges

One major cultural challenge was to make engineering HE teachers grasp the significance of catering for the student as simultaneously an English language user in a particular field of expertise.

This was connected to the further challenge for both engineering and English teachers to plan and work in tandem or together on an interdisciplinary collaborative approach. This required articulation of academic and scientific discourses beyond text or corpus analysis of the language features in texts (lexis and grammar). Both students and teachers were required to negotiate across their own cultures of/for learning and teaching in order to come up with a meaningful learning sequence.

4. Some Conclusions

To sum up, there are two points that can be argued for strongly in relation to CLIL and technology-enriched learning environments (or even web-based instructional design).

One is the need for the critical understanding of English as lingua franca and language for instruction in relation to discourses of sciences, technology and education. English may be a language for international communication, but it is also a language tied up with the academic and professional identities of its foreign users. Despite the role of English as an international gamekeeper, teachers and students need to focus on their own cultures, histories and academic literacy (Van der Walt, C. & Kidd, 2013) and how they cross-fertilise. Standardised E-courses and E-materials, as available through MOOCs, need to consider this dimension, if they are to help students come to terms on how they can use English effectively for authentic purposes.

As giving English an unprecedented status in 'internationalisation at home' disrupts, the 'local language ecologies as a consequence' (Phillipson, 2009), in the globalised world of today, the undue advantages that native speakers of English may have should be strongly weighed against the high level of cross-cultural awareness and intercultural competence that can be built into blended or E-courses that cater for foreign audiences and their negotiations of meaning. This means integrating into these courses strategies to promote and disseminate local cultures in content and pedagogic practice. Using a combination of languages (at the level of a course programme or a discipline itself) seems to be a more culturally effective strategy in this sense than using just English as a language for international academic learning, research and publishing, although this implies supporting effective bilingual

teaching strategies (David, 2013), which would have to be researched by Engineering students themselves.

One second aspect identified is that using conceptual material written in English for a native audience does not work in the same way with non-native speakers (Clegg & Afitska, 2011). Since most of the CLIL-oriented programmes described are multicultural in nature and involve diverse linguistic and cultural communities, it makes sense to promote culturally linked interpretations in the training of engineering teachers but also of classrooms and learning practices through international CoP. This requires a greater emphasis on strategies for participation and for negotiating meaning in different discourses by raising awareness to cultural dispositions and practices, besides the technical disciplinary competence (knowledge as cultural information). Engineering teachers should help learners to interpret the social and cultural context of particular cultural practices and meaning and to transfer this knowledge to other cultural sites by creating new discourses through participation.

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