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Interdisciplinarity and collaboration in higher education engineering courses: lean thinking applied to teaching and learning

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Abstract

Aim. The aim of the research is to discuss if the lean thinking methodology may contribute to enhance interdisciplinarity and collaboration in higher education engineering courses, namely when applied to engineering students at a Portuguese Higher Education Technology School.

Methods. Lean thinking is an organisational methodology that uses innovation to organise and optimise human activities with the aim of eliminating waste. This methodology can be applied to a wide range of activities envisaging to mainly perform tasks that effectively add value to the related processes. When used in an educational context, this approach may also contribute to identifying which activities successfully contribute to add value to the students' learning process, as opposed to being ineffective for that aim.

Results. Current study focuses on interdisciplinarity through a set of collaborative Content and Language Integrated Learning (CLIL) tasks that were planned, tested and assessed in an engineering Higher Education context.

Conclusion. One of the main aspects envisaged through the developed CLIL tasks was to contribute to the enhancement of peer-to-peer collaborative learning in an interdisciplinary context, another was to reflect on reciprocal cooperation methodologies that enhance interdisciplinarity in Higher Education.

Key words: Engineering Education, Collaboration in Higher Education, CLIL, Interdisciplinary learning and teaching in Higher Education

INTRODUCTION

In a previous article (Gaspar, Régio, & Morgado, 2017) it was argued that it is crucial to teach the next generation of engineers to implement effective operational and organisational changes in elimination of waste, energy and material resources efficiency, as well as on reduction of unnecessary consumption in what was designed as the lean-green manufacturing process. The authors also argued that this change in profiling engineering education was connected to the way in which students are taught and learn in Higher Education institutions. The aim should be to promote and develop students' skills and competences to learn to think lean and act longer term change. It was therefore proposed that collaborative learning methodologies, such as those enhanced by the CLIL approach (the integrated learning of language and content) through the in tandem teaching of Higher Education lecturers in a content specific area (or disciplinary subject) and in English (for Specific Purposes) might pedagogically reflect this lean-green waste elimination strategy and promote different attitudes to learning and working in students that are on the whole more efficient.

Collaborative learning was then defined, according to Stephanie Teasley and Jeremy Roschelle, "as a learning situation during which students actively contribute to the attainment of a mutual learning goal and try to share the effort to reach this goal" (Teasley & Roschelle, 1993). Students do this individually, in groups and in social interaction in class, thus in the process building knowledge and developing skills and competences that are valuable in the working place.

Collaboration in tandem teaching was also presented as reciprocal interdisciplinary cooperation among Higher Education lecturers, in that case the content teacher and the English teacher in its many models (where one teacher assists the other teaching; where both teach in turns; where both teach alternately or where they work as a team).In tandem teaching is thus a kind of co-teaching in which both lecturers commit to work together in order to plan, organise, instruct and assess the same group of students, while sharing the same classroom to impart specialised knowledge in an integrated way (Hartnett, Weed, McCoy, & Nicole Nickens, 2013).

It was also argued that this type of collaborative teaching, when teachers belong to and work in diverse disciplinary areas, as for example, English and Industrial processes, constitutes hard work as it requires the development of specific collaborative skills and competences, the willingness to cross disciplinary borders and the belief that this crossing is productive for their sakes and for the learning of students.

The type of collaboration we wish to engage with through the in-tandem work of Higher Education teachers in this article goes beyond cross-disciplinary communication in which the English for Specific Purposes (ESP) teacher might request the Industrial processes engineering teacher to share his/her expertise on a specific topic to be approached in the English classes. In this case both the ESP teacher and the Engineering teacher continue to operate from within the comfort zone of what they know and teach, as the ESP teacher,

while stepping for some time out of his/her comfort zone to enquire about something from a different discipline will soon return to the comfort of teaching from the perspective of ESP.

However, interdisciplinary teaching and learning requires another type of collaboration, namely that both teachers leave the comfort of their expertise areas and negotiate an in-between grey area of both disciplines. A good example of this is specialised vocabulary as the knowledge of domain specific language in the mother tongue will need to be learnt in English and requires both the ESP teacher and the content specialist to interact from their own specialist areas into finding the appropriate terms, terminology and content specific language in English that will be useful for students to engage with. This is neither easy nor peaceful, because each teacher will have to suspend what they think they know and explain it to the other to reach agreement. Some code-meshing (shuttling between language communities), for example, will be needed (Canagarajah, 2011a); some intertextual issues will arise between English and the mother tongue of the teachers that will need to be sorted out prior to teaching, and the national (domestic) point of view on a topic will need to create space for an international perspective (since English is most of the time used as a lingua franca).

Thus, in this article we will attempt to look further into a task-based approach (Gaspar et al., 2017) adopted at the Polytechnic Institute of Castelo Branco, Portugal as a result of in tandem teaching of an ESP teacher and a lecturer in Industrial Engineering processes while attempting to teach through a CLIL (Content and Language Integrated Learning) approach (Morgado, & Coelho, 2014). This approach aimed at promoting the students' communicative proficiency in ESP, their motivation to learn English and through English, to enact some kind of internationalisation at home, and to emulate similar to work environment conditions.

The roles of both teachers will be examined as to the co-teaching (Hartnett et al., 2013) in tandem models (Karjalainen, Pörn, Rusk, & Björkskog, 2013), their collaboration patterns, and the difficulties they perceived in collaboration. These teacher perceptions will be combined with students' perceptions collected during the tasks on how they engaged in learning. Conclusions will show that Higher Education needs to move towards more collaboration among teachers, more interdisciplinary approaches to content and the integrated learning of content and language as these facilitate the development of rich learning engineering environments where students can become active co-constructors of their learning and develop attitudes, skills and competences that are valued in the global workplace.

A TASK-BASED APPROACH TO CLIL

Task-based learning (TBL) (Frost, 2004; Willis, & Willis, 2007; Willis, 1996) is centred on student resources to complete a specific set of procedures or solve a problem and thus represent a scaffolding for learning process. Furthermore,

in TBL students will focus on the task and not on the language and will engage more spontaneously in communication. In fact, as students complete the task, they are learning language and a specific content. Thus, task-based learning is particularly well-suited to a CLIL approach. In TBL students use their own language resources and those of their pair or group and thus learn through use. TBL starts from student experiences or previous knowledge that may be supplemented by teacher input and thus supports diverse classrooms and diverse linguistic competence (Pérez-Vidal, 2015).

TBL also works with natural language in the sense that the student will not be exposed to selected chunks of language chosen for the classroom, but will encounter a range of lexical forms in his/her search for materials and resources needed to complete the task.

Tasks generally require from students some kind of planning (individually, in pairs or in groups) on what they need to successfully complete the task and how to report on it in written or oral form to the teacher or the rest of the class.

In this pilot experience TBL was integrated with recourse to useful ICT resources as this is an Engineering course and students have been shown to prefer computer-mediated learning. The tasks were designed to include the combined teaching and learning of both language (English) and content (sustainability aspects of the students' engineering fields). The tasks were proposed to the students in a sequence aiming at the increased autonomy of the students in a peer-to-peer collaborative self-learning process, requiring less and less intervention by both content and language lecturers. It was also intended with such a sequence to promote an increasing engagement of the students with the blended/online TBL process.

The first CLIL task was split into two distinct parts. One was purely collaborative and had to be carried-out online by the group of students, whereas the second one was individual, but required a face-to-face presentation to the class. The first part of the task required composing a collaborative text using a Wiki page created by the students, where they had to identify and reflect about the relevance of Lean Thinking in their everyday life. In the second part of the task, each student had to make a presentation to the class about the findings they had come up with within their collaboration, as well as give some personal examples on how to apply such findings in their routine as an engineering student (or as future professional engineer).

The second CLIL task was also of a blended online/face-to-face nature, as it required students to start with an oral class show-and-tell activity – where they identify sustainability aspects related to their engineering fields – and then proceed to a written task that enhanced language learning aspects. Thus, students had to compose a structured text about the main sustainability characteristics referred to in the initial oral task.

In the third – purely online – CLIL task, students were invited to select a specific video and share it with the class using the online learning platform. The video had to convey some sustainability aspects related to the students' engineering field. When sharing the video, each student had to point out the

sustainability related content of the video in the description field of the online learning platform. No repeated videos were allowed. Students also had to view their colleagues' videos and descriptions, as well as grade them. Every grade had to be justified through a small text supporting the proposed grade.

The fourth (and last) CLIL task was carried-out completely online by the students using the dedicated learning platform. In this task students were invited to perform a live online chat session about the topic of Lean Thinking and the challenges and opportunities that such methodology presents to their future work as engineers. Each student had to make (at least) ten entries to the online chat session, but in the end, students were so engaged that the number of entries largely surpassed the initial requirements. All entries in the chat session were recorded for the teachers to later assess the students' individual contributions and for the students to review their own – as well as their colleagues – points of view, as a way to prepare themselves for the final course assessment. Each task required students, on completion, to do some kind of reflective self-assessment on what they particularly liked or disliked in the task performed.

The role of teacher collaboration

There are challenges in planning, preparing and implementing the tasks described above. The two teachers had already been collaborating and experimenting with the CLIL approach for over three years and had thus been able to adapt to the needs and perspectives of each other.

At the planning stage, teachers identified what may be called strategic translanguaging issues (Canagarajah, 2011b), namely code-meshing, intertextual issues, national point of view on a topic articulated with the international perspective, evaluation of source materials in both languages, planning towards bilingual or multilingual goals, how to bridge the gap between learning English and using English to learn about a specific Engineering content topic, as well as content analysis, to make it accessible to students with reference to language structure, redundancy, degree of interactivity and speech rate. Shuttling between language communities is usual and normal in class since Erasmus students, using English to communicate, and Portuguese native students are part of the class. Occasionally Spanish students come to class and three languages are used. During the preparation stage of the CLIL tasks, the language of the materials to be used is one of the key aspects to take into account. Even though most available materials are usually previously prepared in the students' native language (Portuguese), the question arises that it is seldom an effective option to translate them into English; so, when teaching through English, alternative English-based materials need to be selected.

One key aspect of the CLIL tasks is use of the correct (content) technical terminology and to motivate students to learn the foreign language through content. Therefore, intertextual issues usually arise between English and mother tongue

of both content and language lecturers. Whenever learning specific technological content, and since English is used as a lingua franca, terminology is most of the time in the original language (English), since it doesn't have a translation into Portuguese. The domestic point of view on a topic is then many times articulated with the international perspective without raising additional problems.

Considering the teaching and learning process of both content and language in a CLIL context, evaluation of source materials in both languages is always advised. The challenge for the content teacher is thinking how it will be conveyed to the students and how they will learn the language in such context. As for the language lecturer, it is key to understand which content topic is most useful for the students so that they improve their learning process and get more engaged with the proposed class and learning dynamics.

Occasionally, when Spanish Erasmus students are part of the class, teachers have to plan the lessons towards multilingual goals instead of the usual bilingual (English and native language: Portuguese) aims. One of the central questions while planning a CLIL module is how to bridge the gap between learning English and using English to learn about a specific Engineering topic. The learning of a language is (or was) most of the time associated with isolated grammar and structure aspects of the language. The question remains, "How can the teachers use the language to help students learn a specific engineering topic?" and "How to make them, at the same time, understand the language structure to be used?". Thus, helping students with the domain language which will allow them to learn a specific content is the big question lecturers face while planning their CLIL classes.

Finally, in the preparation stage of the CLIL tasks, the scaffolding, i.e., analysing content to make it accessible to students taking the language aspects into consideration is what usually takes more time to prepare. Even though time-consuming, scaffolding is possible using a wide range of diverse tasks, focusing on fundamental (content and language) aspects to convey to the students and developing situations to make students aware of their learning outcomes. To help students consolidate the new learnings, as well as to make them realise what specific knowledge was learnt in each CLIL session, a collaborative glossary is being built by students to be further used by the class, and by future students alike. Cumulatively, self-assessment moments to reflect upon what they have been learning are also proposed.

All preparation stages are possible due to the co-teaching nature of the CLIL tasks presented above. Considering that both content and language lecturers interact collaboratively addressing their specific domain learning goals, the developed CLIL sessions result from a joint effort to develop efficient teaching and learning processes, such as those resulting from the Lean Thinking nature of the tasks.

At the implementation stage, the collaborative nature of the teaching remains, with both lecturers addressing the class simultaneously. As the CLIL sessions were envisaged to promote students' self-learning abilities, initial tasks were blended learning sessions, with online and face-to-face moments throughout the initial tasks, mainly to guide students on peer-to-peer interac-

tions. It is the lecturers' experience that blended courses are adequate for engineering students, as they interact very well with digital resources and enjoy the type of learning they can do digitally.

Since CLIL is a student-centered approach in-tandem teachers always focus on specific task sequences they think address students' needs from the content and the ESP perspectives. By working together, it was easier for co-colleagues to select a diversity of the tasks as an important strategy to motivate learning; another strategy was to introduce different tools to provide students with diverse types of learning. Classes and tasks were always adapted to students' needs and changed whenever necessary.

One of the most challenging aspects was when students did not respond well to the tasks in class. That was when co-teachers had to adapt what they had previously planned and improvise. This requires mutual trust. An example was that sometimes students understood what they needed to do, but for some reason felt they were unable to express themselves in English as they could do it in their mother tongue. Every time students expressed this need the language teacher helped the students with language structure that would allow them to solve the task. The same method was followed when students didn't understand the content and because of that were unable to complete the task, although they had the necessary language skills. This was when the content teacher intervened.

At the reflexive stage, after implementation, lecturers meet and write their impressions in their individual teaching logs, so they would not forget about what went well and what needed to be changed or adapted in subsequent CLIL sessions. Students' tasks were carefully analysed and evaluated to examine if content and language had both been learnt, what type of tasks students had felt more comfortable and enthusiastic with, or what needed to be improved. Interviews to native and Erasmus students were also done to collect their perceptions and further analysed to feed into this reflexive practice.

Cumulatively, focus groups discussions took place in class, so that students' perceptions on the in tandem experiment were gathered for further analysis and improvement. Students were also asked to answer short questionnaires on the tasks they had completed.

The pre-planning, class teaching time during implementation and post-class reflection inclusive of data collection from students are techniques used to continuously feed into improvement of tasks and of the CLIL approach, while also reinforcing teacher collaboration. From one academic year to the other tasks are refined to optimise all these aspects.

Conclusions

The cohesion of the team of teachers who engaged in in-tandem teaching and the quality of the tasks developed for their respective classes, the effectiveness of their experience among the students involved may encourage other

practitioners do use the CLIL approach, collaborate and do interdisciplinary work in Engineering courses.

Task-based approaches and the classroom management systems and practices that may result from collaboration, in tandem teaching and interdisciplinary teaching can make a difference in the learning of students and in particular in developing their own attitudes, skills and competences for team work, collaboration and problem solving in a foreign language. These are valuable skills for the workplace.

In order to be successful this experiment in in-tandem teaching considered the planning stage, the implementation stage and the post-implementation stage as necessary collaborative spaces for collaborative design and team work. This model was then replicated into the task design and thus enhanced the students' collaboration.

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