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The Emergent Role of Mind-Mapping in CLIL Instruction: Textual Cognitive Resources in Engineering Lectures

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ABSTRACT

Starting out from the notion of irradiating thought or conceptual maps (Buzan 1986, 2002), recently and explicitly tackled as an academic skill by some CLIL learner-oriented materials, this article explores the prospects for its introduction in engineering environments. It reports on a small-case study aimed to reflect on the implications of lecturers' textual choices for the note-taking habits of engineering students and ultimately for their representation of contents. The analysis of seven engineering lectures in English and Spanish in a summer seminar for EU polytechnic students, of seven condensed lectures in English by engineering teachers during an in-service training course at the Universidad Politécnica de Madrid and of twenty questionnaires probing into the students' note-taking routines, suggests an influence of lecturing style on note quality and evidences several lecturing deficiencies at the rhetorical level that may hamper the practice of conceptual mapping.

1. Introduction and research objectives

Most polytechnic universities in Spain have traditionally suffered from an excess of monologic teacher centred instruction—from *talk-and-chalk* lessons (Mason 1994: 199), exacerbated by the generalised teaching habit of giving one's back to the audience while engrossed in long calculations on the blackboard. Within this class dynamics, students' participation is notably restricted and their pedagogical support limited to note-taking and written aids such as complementary dossiers or slide print-outs published by the institution's reprography service, although they are not always available and when they are tend to replicate

the numerical problems solved in class with a minimum amount of verbalised information. Furthermore, in core and massively populated early-year subjects such as Chemistry, Applied Mathematics or Fluid Mechanics it is not customary to provide students with additional sources or to encourage active on-line and library searches. Heir to this deeply entrenched academic situation, many engineering instructors willing to undertake teaching in a FL are progressively noticing the need to improve the quality of classroom discourse and lecturing styles, so that students can capture and process the information delivered more efficiently. This has been the unanimous feeling among the science and technology teachers enrolled in the in-service training courses at Universidad Politécnica de Madrid (UPM), recently held at its Institute of Educational Sciences (ICE) and aimed to equip them with the discursive and methodological strategies necessary to face the CEFR standards in English.[1] The objective of this paper is precisely to investigate the main trends of teachers' talk and their possible impact on content comprehension and note-taking, and in particular on its *mind-mapping* variant. To this end, a small-scale exploratory case study from the Faculties of Engineering at the UPM, involving a corpus of twenty students' responses to questions probing into their note-taking habits and the lectures given by eleven teachers (three in Spanish and eleven in English), is presented from a basically qualitative perspective, drawing on data obtained through questionnaires and class performances.

2. Antecedents in note-taking pedagogy and research: the benefits of mind-mapping

Some of the most recent CLIL materials for secondary education are beginning to lay special stress on the explicit training in study skills. *The Oxford Student's Dictionary for Learners Using English to Study Other Subjects* (2007), for one, devotes its central pages to genre-oriented writing, graph interpretation and note-taking. With respect to this latter, what we know as *mind, brain* or *web maps* (Buzan 1986, 2002), either in the form of *spidergrams* or *concept diagrams* (see Figure 1), are shown as especially prominent in the assimilation of complex notions. Through the spatial dimension (i.e. through the contrasts distance/closeness, centre/periphery and the use of the page along the horizontal and vertical axes with left/right and top/bottom positionings) they highlight the relationships between and among concepts, starting from the centre with a knowledge node or key idea and expanding outwards in multiple directions by means of lines and arrows (i.e. *branch-outs*) that indicate the causal and hierarchical relationships connecting the various subtopics and aspects. Occasionally they may employ key words, images and even mathematical symbols to label or illustrate those relationships and thus make them more visible and easier to learn.

In the teaching of L2 writing mind maps have been part and parcel of process approaches such as Flower and Hayes' (1981) or White and Arndt's (1991). For all four authors the process of writing is influenced by the task itself and the writer's long-term memory. They emphasise that writing is done in stages of planning, drafting, revising and editing, which are recursive, interactive and potentially simultaneous. Planning involves defining a rhetorical problem placed in a context, and its components must be explored to arrive at solutions which can be eventually translated on to the page. To generate ideas and organise the information

drawn from the student's memory (whether episodic, semantic or unconscious), White and Arndt (1991, chapter 2) facilitate several brainstorming techniques, among which spidergrams appear as a type of "structured notes" (1991: 34).

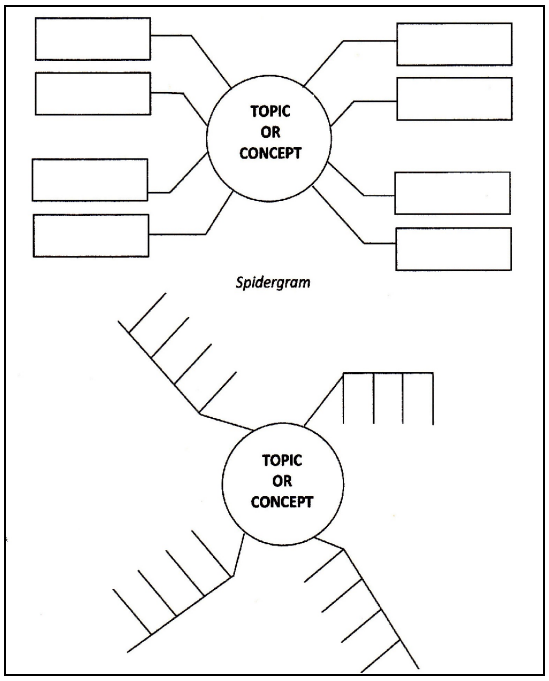

Figure 1. Conceptual map.

But how can mind maps help polytechnical students take better notes? Which is their specific contribution to the assimilation of class content? It is well established that note-taking quality may vary considerably among subjects and cannot be viewed directly as a measure of comprehension (Chaudron, Loschky & Cook 1994: 89). According to Jordan (1997: 7), notes in general may be seen as adjuncts to receptive skills (i.e. listening, reading), as lead-ins or links with productive ones (i.e. speaking, writing) and as mnemonic and attention-sustaining devices during the lecture. As far as all these properties are concerned, there is no solid proof that mind maps should in principle outperform the rest of note types. In a cognitive line, however, several researchers have pointed out the pros and cons of the different note-taking systems. Kiewra and Fletcher (1984), for instance, provide evidence that students who take down key ideas (i.e. *point-driven* note-takers) do better than factual ones (i.e. *information-driven*) on all levels of test items—factual, conceptual and relational, and in this sense mind maps may prove extremely convenient. In the first place, they are point-driven notes since they consist in a concise representation of basic concepts and relationships (e.g. cause and effect, classification, composition and exemplification), which ramify progressively and are in turn the major constituents of science and technology lessons.

Secondly, branching-outs are deemed to be more memorable than *linear* (i.e. vertical listings) and *propositional* (i.e. narrative) notes because of their visual impact, despite the

headings, numberings, underlines, indentations and abbreviation symbols inherent to these two conventional methods. Oxford (1990: 17-19) underscores the importance of memory strategies (i.e. of grouping and associating, as well as of using images) to create mental linkages, and of cognitive strategies to analyse, reason and build a structure for the informative input and output. Thirdly, mind-mapping does in fact activate many of the micro-skills necessary for academic listening enumerated by Richards (1983): the identification of purpose, scope and topic, of the connections between ideas, of the role of discourse markers and key lexical items, or of digressing moves, among others. Let us not forget, nonetheless, that these desirable abilities on the part of the students depend in large measure upon the clear articulation of instructional speech, regarded by the CEFR (Council of Europe 2003: 96) as an indispensable condition to guarantee the grasp of key-points by independent language users (levels B_1-B_2) at lectures and seminars.[2] In addition to the visual and discursive factors, for psychologists and cognitive linguists the foremost advantage of mind-mapping is that it satisfies the natural irradiating tendencies of the human brain, which seeks *gestalts* and completion (Revilla Fajardo 1999, Rivera Lam 2004). Also, it favours the development of multiple associative thought, underlying ever-bourgeoning genres like the electronic hypertext (Rivera Lam, 2004).

On the whole, note-taking research and pedagogies have followed two chief strands: methodological and academic, none of which has tackled mind-mapping but tangentially, as a comprehension-testing task to be completed by students. Strictly methodological approaches (Maley & Duff 1990, Ferguson & O'Reilly 1984, Underwood 1989, O'Connell 1992) focus on the potential problems generated by differences of stress and intonation, pauses, conversational fillers and non-verbal clues in a FL. They offer recordings and scripts about heterogeneous topics and check comprehension by means of true/false questions, multiple-choice tests and gap-filling exercises. From time to time they may even ask learners to write summaries and outlines (sometimes as spider and conceptual diagrams—cf. Widdowson 1978: 127), rephrase sentences, spot the gist, answer open questions or do role plays.

Academic studies, by contrast, revolve around discourse structuring and its lexico-grammatical realisations. Several of them (Chaudron & Richards 1986, DeCarrico & Nattinger 1988, Clerehan 1995) point up the crucial role of discourse macro-markers (including conversational fillers) in the stimulation of high-quality recalls, while others (Dunkel & Davis 1994) suggest that ESL listeners' understanding of lectures is not improved by the addition of rhetorical signals and cues. Some are even concerned with the effects of listening strategies—*information* or *point-driven* (Olsen & Huckin 1990, Dudley Evans 1994), with the type of discourse, such as the research by Tauroza & Allison (1994) into complex argumentation and basic problem/solution patterns, or with the need to address metadiscursive items separately (Aguilar & Arnó 2002), given that the utility of signposting elements seems to be determined by the listeners' knowledge of the FL and so they may turn into 'redundant noise' for advanced students but be really helpful to the less proficient. All these topics researched by the academic strand can affect mind-mapping directly and yet remain to be integrated in the study of its structure and layout in university environments.

From our CLIL perspective, and together with all the benefits commented so far, mind maps can be considered valuable multimodal tools reflecting *critical thinking* and

encouraging *continuous learning* and the use of diverse cognitive channels (visual and verbal). True, Kress et al (2001: 24) examined thoroughly the arrangement and function of mind-mapping in English science classrooms and noticed it might undermine the authoritative attitudes habitually imposed by the discipline or by dogmatic instructors, whose commanding mind-set is synthesized by the slogans *"I have the knowledge—see it my way"* or *"This is the way experts think/act"*. The reason is that the creation of a mind map involves personal analysis, synthesis and evaluation much more than linear and narrative notes: some items are excluded in selecting others and the conceptual bonds and relationships displayed and their representation result entirely from the learner's choices and decisions. Kress and his team (2001: 101) perceived a great deal of variation in mind maps even though students had been given the same instructions and material resources to produce them and had attended the same series of lessons.

By and large, such versatility had to do with differential understandings of the topic, divergent interests and aesthetic preferences which showed in the means of composition and directionality. That is, some maps used boxes, others circles, lines and arrows that could be thick or thin, long or short, bold (to indicate modality) or not, solid or dotted. A few resorted to full sentences and mathematical signs whereas the majority made use of succinct keywords. And there were radial, circular, left-right and top-bottom organisations to depict narrative and descriptive data. Mind maps are therefore *open semiotic systems* that help teachers know their students better, which enables them to opt more accurately for one methodology or another. Kress et al (2001: 118) insist on the difficulties for assessing mind maps and in their inspection suggest shifting the pedagogic focus from correctness (e.g. *"Did they get the information right?"*) to motivation (e.g. *"What made them choose this specific representation?"*). In any case, they are not exempt from culturally-bound semiotic conventions: as readers of Roman script, we assign the informative value of *theme* (i.e. *given* or *known* content) to the horizontal elements placed on the left, and that of *rheme* (i.e. *comment* or *new* information) to those to our right. Similarly, the top items along the vertical axis tend to embody hierarchy and ideal notions (i.e. superordinate categories and *"what should be"*) and the bottom ones represent subordination and reality (i.e. minor categories, class members, examples and *"what there is"*). Lastly, centrality, as before explained, stands for the nuclear information on which all other items are dependent.

As for the role of mind-mapping as an agent of continuous learning, it enhances the idea that the acquisition of knowledge is *a transformative process of sign-making:* students reshape what they read, see or listen to and may disassemble and reassemble those contents to make them newly meaningful. Contemporary CLIL approaches such as Iancu's (2002), with her emphasis on the need for notes encapsulating the most relevant points of lectures and exposing patently the links between ideas, have paved the way for the exploitation of mind-mapping in higher education settings—it is now up to content teachers to disseminate their use. In the light of the previous literature, the present study intends to answer the following research questions: What is the weight of mind-mapping among UPM students? And how much do the lectures given by their engineering instructors lend themselves to it?

3. Recourse to mind-mapping in engineering environments and related discursive cautions

To determine the incidence of mind-mapping in the note-taking habits of UPM students, twenty volunteers were administered a questionnaire to self-report on their routines for processing class information. Four questions were posed: 1) *What do your class notes usually look like?,* 2) *Do you think the quality of your notes depends on the teacher's style?,* 3) *When taking notes, do you try to get only key ideas, as much as possible, or everything to the letter?* and 4) *Say whether you use notes as your primary tool to prepare exams and whether you revise your notes soon after class, expand them using other sources and borrow those from your fellow students to compare and fill gaps.* The subjects who took part at this first stage of the study, aged 20-22, were students of aeronautical engineering in their second year and with a level of proficiency in English ranging from low to high intermediate. All of them were native Spanish speakers taking the sixty-hour and English-medium elective *Technical English.* Questionnaire responses revealed that, analysed as a product (see Graph 1), students' notes are mostly vertical outlines with optional numbered or lettered headings and subsections. A modest proportion take the form of dispersed keywords or sentences, sometimes interconnected with arrows or lines, and branch-outs[3] and mappings binding together balloons, boxes or drawings appear to be scarce. It is noteworthy the unexpected abundance of block-style notes in an engineering environment (i.e. of pages with no divisions or paragraphs but with sporadic word and sentence highlights), which reach 40%. Finally, the vast majority of students (80%) believe the quality of their notes is largely influenced by the lecturing mode.

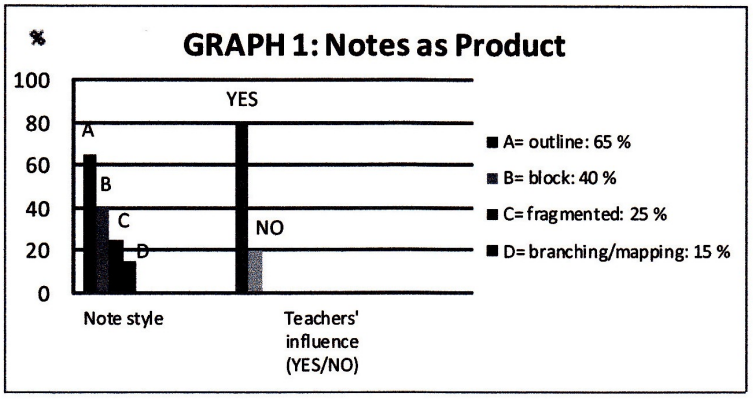

Figure 2. Notes as Product.

Viewed now as a process (see figure 2), half of the informants aim to write down only the key points, and in an equal percentage attempt to take in 'as much as possible', although not verbatim. With regard to their post note-taking habits, a moderate proportion of the subjects surveyed revises notes soon after the class, half of them borrow those from classmates to compare and fill gaps before examinations, and a slightly bigger group usually expands their notes with outside sources. For a substantial majority (70% of participants) class notes are the

major tool to prepare exams.

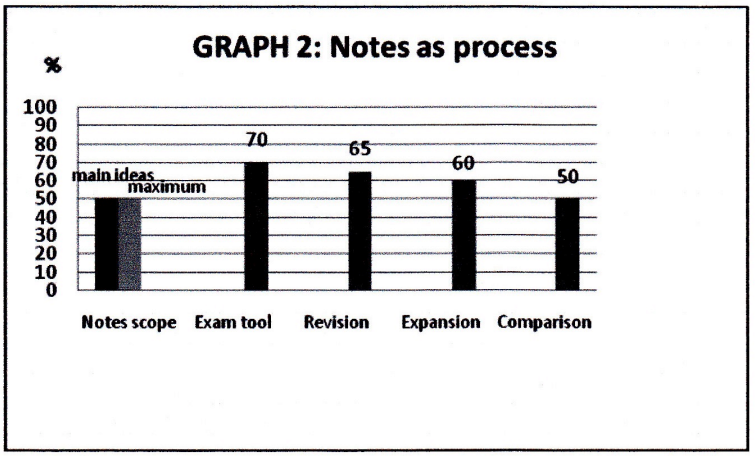

Figure 3. Notes as Process.

From all this it can be gathered that mind-mapping and branch-outs are relatively untapped *note-taking* styles as compared with the linear and propositional alternatives, and that post-class note elaborations are less frequent than expected in spite of their essential role in exam preparations. If our intention as CLIL practitioners and advisors is to boost branching notes and mind-mapping, we should promote them first as strategies for *note-making* (Jordan 1997: 187) so that students can acquire the necessary expertise for *note-taking* under no pressure, simply by handling class contents creatively at home or during workshop activities. It is worth-heeding, by the way, that Kress et al's survey on mind mapping structure and arrangement (2001) was grounded in the post-lesson processing of lectured concepts. Simultaneously, we should furnish the technical staff with tailor-made lexico-grammatical glossaries pivoting on categorisation (that is, on composition and structure) and encompassing the many modalities of definition.

There is a triple argument behind this statement: categorisation (i.e. classification) is cardinal to the tool to process the information (the mind map), to the mode of transmission of knowledge (the lecture) and to the discipline (ESP and specifically EST—English for Science and Technology). To begin with, as Kress et al remark (2001: 118), mind maps are in themselves more or less complex taxonomies expressing relational meanings denoting hierarchy, properties or constitution and transactional ones with clear actors, processes and goals (e.g. actions like *produce, release, return, cause,* etc.).[4] The second argument is that, unlike problem seminars, the 'more verbal' engineering classes studied here lack an all-embracing problem/solution pattern framing the whole session, and start instead from a series of definitions and categorisations enriched with descriptive fragments (either static or of processes) and illustrations, being intermittently interrupted by problem/solution embeddings. All in all, then, the mode of transmission and the tool to process its contents seem to fit because both rest on the same discursive function—classification.

The third argument is provided by Trimble's discursive approach to scientific-technical English (1985: 11). It holds that the identification of classifications, definitions and

descriptions, which he calls *specific rhetorical functions*, is vital to the full understanding of technical texts. They fulfil more ample rhetorical functions (e.g. state objectives and problems, report past research, or present information on apparatuses or experimental procedures) subservient to overall discursive goals such as to detail an experiment, make a recommendation, or inform about new hypotheses, theories, or other scientific issues. Of course, specific rhetorical functions can be recognised by what Trimble terms *rhetorical techniques,* certain kinds of relationships he divides into *orders* (i.e. temporal, spatial and causal) and *patterns* (i.e. causality and result, relevance, analogy and contrast, and exemplification/illustration). Making these interwoven functions and techniques clear when using a L2 entails that technical content teachers mind their micro-linguistic realisations at lexical and phrasal levels, as well as the syntax and the global organisation of their classroom discourse. To achieve that they should build on functional repertoires, as copious as possible, that help them gain self-confidence and enable students to distinguish between central and subordinate categories and work out the connections among them and with further subdivisions and points.

On the other hand, content instructors should be urged to resort to *complete classifications* rather than to *partial* and *implicit* ones (Trimble 1985: 85-95) whenever possible, and to spotlight and reiterate them moderately in the course of the lecture. Whereas *partial classifications* only give the name of the class and list some of its token-members (C + T structure), *complete* ones mention the concrete item or class member, the class to which it pertains, and the basis or criterion for categorisation (C + T + B). Much less informative, implicit classifications may hint at these three elements (C + T + B) since they are present in the text, but retrievable only through inferential relationships. The written technical text permits a close scanning and scrutiny of paragraphs to unravel the unstated meanings, but the immediacy and rapid flow of classroom discourse makes us suspect that implicit classifications can exert a pernicious effect on note-taking, unless strong visual support and periodic and final recapitulations are systematically provided. In the example below, extracted from a UPM engineering lecture, the listeners are confronted with an implicit classification and left to no other alternative than turning to verbatim note-taking to infer class membership and classifying bases. They are forced into making the following indirect deduction in situ to make out categories and relationships: today = not composites but mechanic materials + today = aluminium and titanium à ergo: aluminium and titanium = mechanic and non-composite materials.

(1) Tomorrow, composites, today, mechanic materials. When I started to prepare this lecture I had a problem because it is not very attractive to start speaking of aluminium, its properties, etc., titanium… (C_{2E})

The emendation of the above example could render more transparent class introductions, either of a (C + T) structure, as in (1.a), (1.b) and (1.c), or complete (C + B + T) with the attachment of the classifying criteria and thus incorporating definitions. (1.a) would exemplify this expansion by including the concepts of *mechanic, non-mechanic* and *composites* and being careful to mark every conceptual transition anaphorically:

(1_{bis}) Today we will speak about the materials used in Formula One cars. There are two classes of materials *according to their physical behaviour:* mechanic and non-mechanic. *The behaviour of non-mechanic materials depends on the direction of an applied force or load, while that of non-mechanic materials is independent from it.* Non-mechanic materials are fundamentally composites. *They are engineered and formed by two or more constituents with different physico-chemical properties and distinct on a macroscopic level.* Examples of composites are aluminium and titanium.

Although exclusively concerned with the written text, Trimble's dissection of the categorisation function provides a very useful framework for mind-mapping, applicable to oral speech. His 'discursive cautions' relative to classifying elements could be fruitfully combined with those underscored by Widdowson (1978: 22-56) for oral discourses in EST teaching: the need for explicit referential reminders (anaphora) and the awareness that the arrangement of sentence constituents has illocutionary consequences. This consideration is fundamental because propositional development, (syntactic order and topical focus) may affect interpretation and the representation of contents as mind map branch-outs and give rise to different discursive functions (i.e. classification, definition, identification, generalisation, illustration, correction, emphasis...). Further elaboration on Example (1), for instance, can yield a number of versions with different illocutionary values:

(1.a) Today we will speak about the materials used in Formula One cars. There are two classes: mechanic and non-mechanic. Non-mechanic materials are fundamentally composites—for example, aluminium or titanium.

(1.b) Formula One cars are made of mechanic and non-mechanic materials. Some of these are composites, such as aluminium and titanium.

(1.c) Aluminium and titanium are composites, non-mechanic materials used in Formula One cars.

The prime function in 1.a and 1.b is classification, although they also contain identifications ("*are* composites") and exemplifications with explicit markers. Both versions present a C + T structure with no classifying basis (B), which would introduce a definition of each of the categories involved (*mechanic, non-mechanic, composites*) and 1.a makes the branching clearer thanks to the numerical anticipation of categories (henceforth NA): *"There are two classes..."*. It can be readily seen that the propositional development in 1.b is more reduced (the anaphora has been compressed by a pronoun) and that is presumably to encumber categorisation while jotting down ideas. The priority in 1.c is in contrast identification, and difficulties might arise here as well for the listener since identifications do not normally present new information but presuppose *givens* or taken for granted notions, which could equally conceal the branching.

In parallel with the former cautionary observations, some extra adjustments should be made when addressing multicultural audiences, and many a CLIL and pedagogy researcher and author (Chaudron 1988, Tauroza & Allison 1990, Miller 2002, Crawford Camiciottoli

2005 and 2007, Giménez Moreno 2008) has insisted on adaptations having to do with speech rate (a slower and more redundant pace), textual coherence and cohesion markers, specialised vocabulary, interpersonal metadiscourse and strategies to mitigate intercultural distance: questions and elicitations, inclusive pronominal references, and even bodily and figurative language, above all metaphorical expressions. The initiative undertaken at the aforementioned ICE-UPM course, enthusiastically welcomed by its participants and to be shortly uploaded onto the local Moodle platform for tele-education, has been to supply engineering teachers with lexical and grammatical inventories covering those facets from diverse angles, namely Trimble's specific rhetorical functions, orders and patterns, Hyland's (2005) taxonomy of *interactive* (textual) and *interactional* (interpersonal) metadiscourse to polish delivery strategies, attending to the argumentative and persuasive quality of lectures (e.g. markers of evidentiality, certainty, doubt, engagement, glossing and repair, topic shifters, endophorics, hedges and boosters, etc.) and Young's (1994) breakdown of lecturing speech into the phases of *discourse structuring* (i.e. introducing objectives and motivation and predicting the direction of the talk) and *exemplification, content* and *conclusion* (i.e. closure and final summary). The combination of Hyland's metadiscursive types and Young's phases can raise the teachers' and students' consciousness of the inner workings of any lesson, show the linguistic resources at hand to mark them, and help students to build expectations and predict the coming information when taking notes. Moreover, other supplementary repertories tackle the rhetoric of subgenres following a problem/solution progression (e.g. case studies and problem seminars) and the omnipresent handling of situational interactions inside the class (e.g. greeting and ice-breaking, asking and interrupting, marking asides, etc.). We cannot overlook either some frequent collocations adding personal hues and simultaneously sorting out all-important from subsidiary information (e.g. *distinguishing, distinctive, main, major, foremost, paramount,* etc. + *feature, trait, characteristic, component, element, attribute, class, variety, sort, type, kind,* etc.) or introducing definitions and criteria (e.g. *"By X we/I mean...", "X is not to be confused with Y"*). Herbert's *The Structure of Technical English* (1965), today a classical among the myriad of ESP methods for engineers, is a fairly typical exponent of this collocational trend at phrasal and sentential level, and its syntactic tables and branch-out word-studies may be convenient implements for non-native English speakers.

4. Teacher's talk: the note-taking context at an engineering school

4.1. The corpora and the approach

My study on the textual choices of engineering instructors and their repercussions on the application of conceptual maps in note-taking involves two corpora. The first corpus analysed, totalling approximately 52,000 words and seven recorded hours, comprises seven transcribed lectures on aeronautical engineering and related fields, four of which were delivered in English by native Spanish speakers and three in Spanish. While the Spanish lectures dealt with subjects within the ordinary syllabus for Aerospace Engineering, the English-medium ones were given to an audience of twenty-six EU students of fourteen different nationalities

participating in the twelve-hour summer course entitled *Feel the Speed. Feel the Engineering. What's behind Formula 1 Cars,* organised by the Board of European Students of Technology (BEST). The purpose of such courses is to foster internationalisation, open-mindedness, cooperation and mobility. All lectures exhibited a marked predominance of verbal information over numerical input and the teachers who volunteered to participate in the study were two male full professors in their sixties/late fifties whose delivery style, although spontaneous, was more formal and rhetorical than interactive (i.e. more autocratic and resembling the role of a public speaker), and two senior lecturers in their mid-thirties (one male and the other female) and with conversational styles (i.e. dialogical and participative). Curiously enough, the most interactive teachers frequently elicited classifying bases (Bs) and token class members (Ts) from students without paraphrasing or summarising them later, an oversight which could seriously damage comprehension in large classes but was not encountered in the more monological lessons.

The second corpus consists of another seven performances by UPM teachers, but this time in condensed form, as videotaped mini-lectures (a total of 124.62 minutes). They were imparted as practical class exercises throughout the latest edition of the in-service training seminar *"Preparación del docente para la enseñanza de contenidos técnicos en lengua inglesa dentro del espacio europeo de educación superior",* which took place at the Institute of Educational Sciences (Instituto de Ciencias de la Educación, ICE) of the Universidad Politécnica de Madrid on May 5-6, 2009. The topics were varied, as were the ages and levels of pedagogical and linguistic expertise of the participants, this latter ranging from low intermediate to advanced. The topics were the following: "Cartographic systems" (Lecture 1), "Software design" (Lecture 2), "Noise-absorbing properties of reed in fitting acoustic enclosures" (Lecture 3), "μ-controllers in electronic systems" (Lecture 4), "Sustainable energies" (Lecture 5), "Thermal treatment of wastes" (Lecture 6) and "Properties of wine and their evaluation" (Lecture 7). Although in some talks argumentation and explanation were dominant, on average they all included two or three simple taxonomies. On every occasion performances were discussed and evaluated by the audience according to parameters such as clarity and methodological efficacy—the speaker's course mates took notes and asked questions to understand the content, motivation and interactivity, which were rated as crucial above grammatical and phonetic abilities.

4.2. Findings in the BEST corpus

No critical differences were found between lectures in the two languages as regards categorisation, except for a marginally wider variety of class-marking nouns in Spanish (e.g. *piezas, opciones, posibilidades, ángulos, ideas, materiales, filosofías, métodos, modos,* etc.). The most outstanding qualitative findings can be summarised into three shared deficiencies that may hinder the mind-mapping practice: (1) a vague and limited branch-marking, (2) an abuse of topic-shift rhetorical questions, and (3) a profusion of *false-alarm* branching. For the sake of clarity, examples have been tagged with a three-notation code registering the lecturing style (C = conversational, R = rhetorical), the language (E = English, S = Spanish) and the lecturer (1, 2, 3, 4).

4.2.1. Vague and limited branch-marking

The four teachers coincide in using extensively words such as *problem, question, situation, solution* and *result* (and their Spanish equivalents). They are known as *signalling/shell/carrier* and *metadiscourse* nouns (Flowerdew, 2008) and indisputably act as textual beacons helping listeners to discover classification criteria and identify the exact lecture stage they are at. In the lecture samples analysed, however, they only signal small problem/solution insertions and do not serve as a base for more refined branching. Some of these items, as Bellés notes (2008: 100), may be synonyms and hyponyms of the classification concept (e.g. *groups, (sub)divisions, categories,* etc.) but in our corpus only *type* and *varieties* have been detected since more specific nouns are preferred (Examples 2-5):

(2) parameters, hypotheses, theories, methods, models, principles, possibilities, approach, difference (R_{1E})
(3) parameters, methods, criteria, contributions, conditions, limitations, restrictions (R_{2E})
(4) possibilities, efficiencies, regulations, ways, energies (C_{1E})
(5) materials, reasons, views, cases, components (C_{2E})

Classifying verbs denoting composition and structure are scarce in both English and Spanish: the only tokens found are the synonym expressions *consist of* and *constar de* (used in provisional summaries) and *differentiate* (6): lecturers confine themselves to presentational verbs (mostly to *there* + *be* and *haber*) (7), to simplified existential constructions with the verb *to be* (8), and to what could be called *pseudo-presentationals,* a Spanish transfer solidarity formula gathering an inclusive personal pronoun (*we, you*) and the verb *to have* (9). The risk of using *to be* and *pseudo-presentational* structures as branch-markers is that more often than not they go unnoticed in discourse and may escape students' notes without adequate emphasizing pauses and visual aids.

(6) So, thermal treatment of aluminium *consists of* a first heating solution treatment to dissolve alloys, alloys elements into—into the lattice. (C_{2E})Into the engine we can *differentiate* several components: for example, static components. (C_{2E})
(7) *There is* another property also related to the chemical bond, is the melting temperature. (R_{2E})
There are at least four parts also in the suspension. (C_{2E})
(8) The first one, for example, *is* the efficiency of the combustion. (C_{1E})
The bodywork *is* another important part of the car. (C_{2E})
(9) And finally, *you have* a let's say, orbital platform, like ISS or other satellite and so on. (R_{1E})
And *we have* here another important fibre… (R_{2E})
Then *we have* the piston. (C_{1E})

Vague branching markers may also lead to conflict: numerals and the merely additive *other* and *another,* if constantly employed as topic shifters (as in R_{2E}'s lecture), tinge discourse with

an extemporised tone that may prevent listeners from knowing when to close the inventories opened. Besides, they do not specify the classification criterion applied. R_2 idiosyncratically collocates the two markers with the evaluative adjective *important,* which creates confusion in the identification of nodal points (10):

(10) *Other* question is there are some requirements about the brakes. (R_{2E})
Another important contribution of the resin is for compression. (R_{2E})
Two important things is that the material has no plasticity… (R_{2E})
Another important thing to discuss is… (R_{2E})
The other important thing to discuss is… (R_{2E})

As seen in the former example, this imprecise effect may get reinforced by nouns like *thing/cosa* and *idea,* too generic to indicate what criterion relates them to a prior conceptual node: the fact that this phenomenon does also occur in Spanish (C_1 and C_2's lectures) suggests that it is likely to be caused by discursive relaxation and not necessarily by a scanty lexical repertoire.

4.2.2. Over-abundance of rhetorical questions as topic shifters

The four lecturers make use of rhetorical questions, but conversational ones to a greater degree. Rhetorical questions frame the short problem/solution embeddings as competently as hypothetical conditionals or overt enunciations (11):

(11) So what we need for the resin? You need just…We need to fulfil these two conditions… (R_{2E})

However, when overused with no parallel visuals (as in C_2's discourse), far from gaining agility they easily lead to a fragmentary speech where the expository progression is hard to discern. Concatenated questions (12) block the echoic and short term memories that decode sounds and process content. Students feel then too rushed to fathom out conceptual links and elaborate their context in order to transfer data to the long term memory for later use, once recoded in a reduced form.

(12) ¿Para qué añadimos carburos? ¿Dónde añadimos los carburos? *¿Qué efecto producen los carburos?* (C_{2S} asking about the purpose of adding carbides, where and the effect they produce)
How can you find aluminium in aircraft? What's for? (C_{2E})

Even though the teacher knows where he/she is driving at with his/her batteries of questions, students do not and may feel the class is going off at tangents, which impels them to take almost verbatim notes so as not to miss anything and construct a coherent class account outside. One more inconvenience of consecutive questions is that the statement of classification criteria gets indefinitely postponed, and thus branching becomes virtually

impracticable. Widdowson (1978: 25) firmly endorses the use of question clusters (whether rhetorical or referential) in the classroom, but only if they conduce to a fluent question/answer dynamics presenting orderly topic shifts and repeating the new information in a non-redundant way to strengthen assimilation.

4.2.3. False-alarm branching

Under the denomination *false-alarm branching* I subsume the listings and divisions frustrated and interrupted by digressions and omissions. It may be caused by varied circumstances: class-opening and key-point introducing NAs, to begin with, are very few (14), so class members and criteria are to be unearthed as the lecture progresses. Amazingly, some lecture staging plans have even been found to happen after ten minutes of talk (15). Secondly, binary parallel constructions get aborted with the oversight or the excessive distance of the correlative term and raise false branching expectations (16). Thirdly, the lecturer may formulate rhetorical questions and announcements that mislead to think a prompt itemisation is coming (17).

(13) Ok. What are we going to use? Very few—let's say, few principles of law. The first one is the conservation of mass, Ok? The second one is the second law, the conservation of momentum, let's say force is equal to mass multiplied by acceleration, is another way of expressing the same principle. The third one is the conservation of energy, which is the second law of thermodynamics. (R_{1E})

(14) So I decided to dismember totally a race car and divide it into different parts and to analyse the materials used on every part of the car. Starting with the engine and following with the surface, the bodywork, the wheels, the brake system, transmission and suspension. (C_{2E})

(15) …there are also some limitations. The first one is that the quality is very critically, eh, that the quality of the product…is very related to the quality of the process. I mean... [the explanation continues and the discourse flow moves on to another point] (R_{2E})

(16) …and well, how you can get microgravity? [digression follows] (R_{1E})
Ok. Now I'm going to explain you some basic ideas of aerodynamics [digression follows]. (R_{1E})

To conclude, *false-alarm branching* not only is originated by the interference of incidental trains of thought but also by pragmatic errors. Lecturer R_1's idiolect, for example, is characterised by a couple of transfer errors which threaten comprehension. He uses the final conjunction or consecutive adverbial *so that* as narrative connector or marker of conclusion or inference, even as an 'ice-breaker' (and sometimes as a conversational crutch or filler), three functions performed by *so*, corresponding to the Spanish *así que/así pues/entonces/luego,* infallibly in sentence-initial position. *Así que* is the literal translation for *so that,* and hence the confusion (18). Analogously, in his delivery *let's say* has come to function as filler and seldom does it mark exemplification (see Examples 9 and 14).

(17) *So that* we need to measure the importance of the ratio of viscosity forces and inertial forces. (R_{1E})

Fortunately, the flipside of all these counter-productive findings is the existence of compensating discursive mechanisms, seemingly style-bound, that help to compartmentalise and memorise contents. While rhetorical teachers are more inclined towards dividing large information chunks under noun phrases resembling textbook headings (e.g. "Microgravity" and Satellite development" in R_{1E}, or "Perfiles: siempre simétricos" in R_{2S}), the more conversational lecturers opt for parallel and triadic repetition, especially in provisional summaries (19). Nevertheless, none of these correctives and neither the hands-on activity in $R_{1E,}$ the close interaction with students in C_2 or the pervasive use of powerful visuals seem to mitigate categorisation flaws.

(18) *We have here the energy* equation. *We have an energy* that is coming with the air coming with the fuel. *We have another energy* that it is going with the mixture to the cylinder. (C_{1E})
Primera forma de perder estabilidad: fluorescencia. Segunda forma: disolución. Tercera forma: transformación en otro precipitado diferente. (C_{2S})
¿Añadimos aluminio normalmente? Sí. ¿Añadimos boro normalmente? Sí. ¿Añadimos wolframio normalmente? Sí. (C_{2S})

4.2. Findings in the in-service seminar corpus

The most remarkable finding in this second corpus is that its teachers did not incur the weaknesses displayed by their colleagues of the BEST course (an excess of rhetorical questions and vague and *false-alarm* branch-marking) despite not having been warned or instructed beforehand. Rhetorical and genuine referential questions were used but sparingly and in combination with comprehension check-ups once the corresponding definition or explanation had been given. The only female participant, by the way, was the speaker resorting to them the most, being pioneer in setting an interactive trend later employed by the rest of her class-mates (see Example 19).

(19) What is reed? (Lecture 3)
Why electricity? (Lecture 5)
What do we mean by 'thermal processing'? (Lecture 6)
What can we pyrolise? (Lecture 6)

Sudden 'another/other', if detected, were not followed by generic words of the type 'thing', 'item' or idea' in vague branch-marking but by concrete (and sometimes reiterated) referents also present in a concurrent slide (Example 20a). That way the audience did not get lost and had enough time to jot down terms and link them with arrows or curly-bracket subdivisions. The incidental addition of items, if any, always included a keyword to identify them in the ongoing taxonomy (20b) and frequently branch-outs were reinforced by gestures (e.g.

counting with the fingers in Lectures 1 and 2).

(20) a. Another *problem* is… (Lecture 2)
Another use is waste treatment. (Lecture 3)
b. *There is even* a better shape to approximate this surface, which is… (Lecture 1)
I am going to talk *other properties* of software apart from complexity (enumerates reinforcing with finger-counting gesture, Lecture 2)

When the words 'idea' or 'concept' were used, it was with the intention of summarising (Example 21a), frequently associated to adverbs preparing the way for recapitulation, like 'basically', or properly retaking a classification interrupted by a short digression (21b). However, in one of the lectures (Lecture 4), the expression "The main idea is…" preceded a lengthy explanation hardly identifiable with the core of the message, when a shorter clause would have been expected.

(21) a. *Basically* the idea is that…
The idea is that you have an organic material but in the absence of oxygen. (Lecture 6)
The main idea for you is that you don't be snobbish when you try wine. (Lecture 7)
b. And then the third concept is pyrolisis. (Lecture 6)

Classifications were based on numerical anticipation and so branch-outs became practicable. Items were in their majority introduced by ordinals (e.g. "First", "second", "third"…, see Example 22a), there might be a co-marking of relevance (see 22b) and at times the numerical anticipation of categories or items through cardinals gave way to them directly, without ordinal markers (22c). This strategy was most often supported by a slide containing synoptic taxonomies, tripartite at the most. Trimble's complete classifications (i.e. C + T + B structures, see again 22c) are more commonly found here than among the BEST lecturers. One plausible reason for this fact may be the short duration of the in-service seminar talks, which should expose few concepts as clearly and thoroughly as possible and lent themselves little to digressions interrupting taxonomies. Another, that these presentations were the evaluative media to assess the attendants' participation, so they made efforts to categorise concepts in a complete and comprehensible way, subject as they were to their peers' feedback, many of them lay people in the field.

(22) a. Ways of evaluating the wine. In wine-testing there are four or five senses (digression). *The first is* SEE (digression). So, *the second is* SMELL or SNIFF, *the third is* SWIRL, *then is* SIP and *the last part* is SUMMARISE. (Classification reinforced by writing simultaneously each item on the blackboard in Lecture 7).
b. There are some serious requirements for this type of energy. *First,* we need a short type for gas production, renewable for each moment. *The second, more important*, renewable generation systems must be regulated and especially accurately regulated, to regulate this production for each moment. (Lecture 5)

There are a lot of technical difficulties for to do that. *The first and more important is*… (Lecture 5)
There are some solutions: of course *the first solution is* a reasonable consumption for this access…*The second is,* of course, efficient systems, *but the most important is* to integrate the renewable energy in electric network systems. (Lecture 5)

c. Depending on the metric property we will have…angles (for example, formal projections), areas, with equal projections and length or distances or measures—they are equidistant projections. (Lecture 1)

Exemplification was distinctively marked, mostly with the prepositional phrase "for example" and instances were sometimes elicited interactively from the audience. The same lecturer had previously employed this technique to introduce the pertinent taxonomical categories (Example 23).

(23) There are many types of wines. I'm sure you will distinguish between white wines and red wines. Do you remember the name of any white wine varieties? (Lecture 7)

But interactive personalization may as well work as a topical lead-in, comprehension check and classroom management strategy (Examples 24a and b, respectively), which are not to be mistaken for the fossilised solidarity formula *we + have,* also detected in this corpus (24c) due to a deficient repertoire of presentational structures. Inclusive pronominal reference *(we + modal verb)* may equally appear introducing categorisations (24d). According to the findings of the SPICLE project (Neff et al 2003), this structure reflects the tendency of the Spanish language towards the interpersonal parameters of solidarity (+ proximity, - power), which may be explained by typological and instructional reasons. In effect, the Spanish modal verb *poder* is polyvalent since it agglutinates meanings of possibility, ability and permission. Additionally, *can* is the first English modal to be introduced in EFL syllabi, being the other modals deferred until upper intermediate levels of proficiency. All this makes learners accommodate in a single-verb repertoire and transfer meanings from their L1 into English, misusing *can* to express epistemic stance as a presentational construction (i.e. instead of "X may be broken down into" à "We can separate X into…").

(24) a. Some of you knows the Globe Theatre in London? It's made of this material, of reed. (Lecture 3)
I want to ask you how many of you know about this 'Guitar Hero' program…What was your impression? Somebody else? (Lecture 4)

b. Can you understand me ok? Do you want me to explain you what is the reverberation time? Have you understood what I mean? (Lecture 3)

c. So *we have* this reference surface. (Lecture 1)
Summarising, *we have* four properties that make software complex… (Lecture 2)

d. There are three ways in which *we can* treat wastes (…) and when they decompose *we can* separate three phases: one is the oil, a carbon, a liquid that can be used as a fuel and also a gas as well. (Lecture 6)

Intuitively, two seminar participants (Lectures 2 and 4) brought in attractive visual stimuli as warmers to make their audience reflect on the topic being introduced—humorous icons and comic strips on software complexity and friendly use. Their awareness of the need for a competent initial discourse structuring and a summarising round-off, nonetheless, was not casual but the result of insistent training. All the same, five speakers missed a final recapitulation of their talk (Lectures 2, 3, 5, 6 and 7), whereas the rest of their colleagues aided it with the projection of 'summary slides'. Summaries undoubtedly help check the validity of one's notes and once more transport the audience back to the 'big picture' outlined at the discourse structuring stage. Table 1 below shows the expressions and approaches for both stages in those lectures which included them.

LECTURE	DISCOURSE STRUCTURING	FINAL SUMMARY
Lecture 1	I will give an introduction and some brief concepts. First of all a definition, then we shall see the concepts and then a brief classification of different types of cartography systems.	We can summarise here we have learnt… We have also seen…
Lecture 2	I want to show some properties in the software. I want you to understand the reason why software is complex. First of all I am going to give three main properties or characteristics: the software complexity—what properties make the software complex, some other problems of the software, and what properties must have a good design. A good software design.	"And that's all" (No final recapitulation)
Lecture 3	The layout I'll follow is this: I'm going to start with an introduction, secondly with materials and methods, after I'm going to show you the test results. Finally, I'll give you the conclusions.	We have seen before… (partial mention towards the end of the talk but not a real final recapitulation)

Lecture 4	So, the contents of this presentation is first to show you the background, the main motivation to do this work, the description of the work, the objectives we want students to obtain, and also want to describe the basic advances in innovative practice. Finally I want to show you the items that we want to evaluate from the students and a demo of the project we are proposing.	I've described the final course project, I've presented you three possibilities of practice and I also made a description of the evaluation we want to do. So, that's all. Any questions?
Lecture 5	We present three items about that. First is how the energy becomes accessible for all body, second if the method to produce this energy are sustainable, and three, if there are some solutions for that.	(No final recapitulation)
Lecture 6	The main objective of this presentation is that you understand the concept of thermal treatment. And also that you can differentiate between three words or concepts. One is gasification, the other one is combustion and the other one is pyrolisis.	(No final recapitulation)
Lecture 7	I'm going to talk about wine. How it is produced and how we enjoy wine.	(No final recapitulation)

Table 1. Discourse structuring and final summaries in all seven lectures.

Perhaps the most serviceable conclusion we may draw from these two corpora is that, as teachers, we should never make too many assumptions when it comes to the categorisation of concepts. The BEST lecturers addressed pseudo-expert audiences (students already with some background in the discipline) and that permitted them to digress more and omit more classification elements that their in-service trained colleagues. These latter spoke to lay listeners and felt obliged to contextualise and aim for precision, mentioning classifying criteria and tokens for each class and making sure knowledge was processed and simplified since it was not shared by everyone. Not all their peers would be able to make the right inferences in order to bridge gaps if any element in Trimble's C+ T + B complete model was dropped. The length of the lesson is another factor to consider, and along with it whether there is any possible continuity to deepen in the subject and review concepts in subsequent sessions.

The seminar teachers knew they had to cover their topic in fifteen minutes or less and so took pains to provide an anticipatory outline before their presentations, as well as visuals reinforcing the taxonomical elements and bases as they explained them. The untrained BEST teachers seemed instead more concentrated on establishing rapport through an interactive style and controlling mistakes in the foreign language.

We have also seen that errors are varied and cannot be generalised. If the BEST lecturers' taxonomies were vague and digressive and their overuse of rhetorical questions confusing, the seminar teachers, having received explicit training in class openings and closures, managed to competently structure their discourse at the beginning of the lesson but most of them forgot to recapitulate the significant points at the end. This evidences the need for systematic training in alternative methodologies that substitute or complement the traditional monologic class, change its pace and give on-the-spot opportunities for a better assimilation of contents. For instance, guided self-discovery techniques that make students build conceptual categories, sorting out and processing the information by themselves. *Chalk-and-talk* lessons require constant monitoring by both teachers and students on two fronts: 1) comprehension and 2) interactive deliveries that do not distract the informative flow and bring about efficient note-taking and note-making (and therefore a competent storage of data for subsequent retrieval). Special care must be taken in offering periodic and and/or final summaries, for example by means of slides, verbal recapitulations and handouts containing all the elements of complete classifications (C + T + B taxonomy patterns) and in elaborating them in a collaborative manner at the end of the session or before starting a new topic in the syllabus.

5. A final reflection

With these first-approach case studies I have attempted to cast some light onto the transmission and processing of information in Higher Education CLIL settings. Its findings may be useful and inspiring for other CLIL practitioners and researchers. Obviously, in long dense lectures mind-mapping is not feasible without solid (numerical) anticipations of categories, classification bases and class tokens at the beginning of the class, supported with more and clearer macro-metadiscursive markers and reinforcing visual aids and materials (e.g. tables, skeleton-prose outlines or blank conceptual maps). Otherwise its practicability will be forever circumscribed to minority *note-making* and never reach *note-taking,* except in brief participative seminars, where the reduced number of students, the alternated floor-taking and the brainstorming involved may leave more room for on-the-spot irradiating notes. If learners are to convert to point-driven strategies, instructors should give point-driven lectures and avoid digressions by carefully planning out the class, anticipating the taxonomies and points to be covered in a complete fashion, summarising more often, increasing visuals, repetition and exemplification without letting them become distracting, devising their own metadiscursive repertoires based on books and in-service courses, checking comprehension in different ways and adjusting their speech to the linguistic competence of their students, always studying their reactions. In exchange, students should come to class punctually not to miss the initial discourse structuring, attend regularly and try to understand the teacher's

idiolect, and learn what to expect and demand from the lecture genre (its component sections and their frequent linguistic cues) and from the disciplinary discourse (its associated rhetorical patterns of problem-solution, description, narrative and possible blends). Both teachers and students should feel members of the same epistemological and discourse community and satisfy their curiosity, sharing cognitive styles and generating and maintaining knowledge.

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Notes

1. Sancho Guinda, C. *"Preparación del docente para la enseñanza de contenidos técnicos en lengua inglesa dentro del espacio europeo de educación superior",* ten-hour course given at the ICE (Instituto de Ciencias de la Educación), Universidad Politécnica de Madrid, 5-6 May 2009.

2. The majority of technical schools in the Madrid area have engaged to ensure a CEFR B_2 level of English for their graduates. Their current linguistic input, previous to the implementation of the Bologna plan at most centres, is still discontinuous and irregular as to its frequency and type of contents, oscillating between four and ten hours of English-medium ESP classes per week and only during certain academic years, when the subjects offered by the Department of Applied Linguistics are available. From 2010 onwards all faculties will share a uniform obligatory subject on the skills required by the B_2 level, as well as preparatory courses to it and assorted monographic seminars on professional communication.

3. It must be borne in mind that mind-mapping always involves branch-outs but not vice versa.

4. The notions of relational and transactional processes used by Kress et al (2001) date back to Systemic Functional Linguistics.

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