Using a combined approach of ontology construction and corpus linguistics analysis to build a course on printmaking terminology

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Abstract
In this paper a combined approach to ESP teaching is proposed, one that combines corpus linguistics techniques and ontology construction. Corpus linguistics techniques have long been used in ESP teaching to provide the teacher with authentic pieces of language usage to guide and monitor classroom practice. Yet, an English language teacher who is not a subject specialist himself needs some guidance as to which are the most salient concepts in the field he is teaching, the breadth of a certain topic and the depth of specialization required. Traditionally, such kind of information could only be provided by a subject specialist. In this paper, a method is outlined for constructing a special language ontology by employing corpus linguistics techniques and the appropriate software. Such a method could prove an indispensable tool for any teacher teaching ESP and provide valuable insight to the labyrinth of special subject knowledge. The special language presented as a case study in this paper concerns the art form of printmaking.

Keywords: ESP teaching, data driven learning, concept maps, ontologies, corpus linguistics, terminology, printmaking

1 Introduction

Although there has been extensive work on the use of corpora in ESP teaching, little has been said on the use of another thriving trend in teaching practice, namely the use of ontologies. Ontologies have seen a wide number of applications in teaching and

learning, particularly during the first decade of the 21th century (Gavrilova T. 2003; Gavrilova et al. 2004; Gavrilova et al. 2005; Silva et al. 2012; Wilson 2004).

Bearing a close similarity to other visual aids such as mind maps, concept maps, graphs and tables, they have been primarily used as a means to capture a domain's conceptual structure. Providing a formal, yet easily extensible framework, they have proved excellent tools for syllabus design which allow the non-expert, e.g. the ESP teacher to make informed choices concerning the breadth of a certain topic, the depth of specialization required and the salience of the information provided. Besides, a well-formed, balanced ontology can he used to harmonize curricula between different lecturers and across educational institutes, e.g. schools, colleges, universities, etc.

Apart from being an invaluable tool for syllabus construction, ontology construction can also prove a classroom activity of high pedagogical value as it helps students develop analytical skills as well as process large amounts of information which can be more easily later remembered. In addition, such conceptual structures once constructed, they can readily be used at the production stage to create summaries, presentations or be used as assessment tools both at the formative and at the summative stages (Silva et al. 2012).

In this work, a combined approach of using both corpus analysis and ontology construction is suggested aiming to enhance the teaching of special language vocabulary to art students using as a case study the teaching of printmaking terminology. The suggested approach comprises the following steps:

- A specialized corpus on printmaking was compiled.
- The corpus was searched for terms, term relations and important collocations involving terms.
- Once the basic terminology was compiled and the relations between terms were pinpointed, the whole conceptual framework was implemented as a printmaking ontology using the Protégé Tool (version 5.00).

More specifically, the paper is structured as follows: Section 2 offers a brief review of corpus linguistics contribution to ESP language teaching. Section 3, presents the tool used for the corpus linguistics analysis. Section 4 presents the methodology followed to construct the specialized corpus. Section 5 presents the corpus analysis findings. Section 6 discusses what is an ontology and presents the methodology followed to

construct one. Section 7 presents an educational scenario for the exploitation of the proposed method in class and finally section 8 presents the conclusions.

2 Corpus linguistics in language teaching

Corpus linguistics has long been used to provide authentic material for teachers and students to study word frequencies, dominant word uses and senses, grammatical patterns, word and word class distribution, suffixation as well as routines in social interaction and major communicative functions.

Additionally, frequency and distributional analysis of language phenomena encountered in corpora have shaped pedagogical choices concerning what to teach, when to teach it and the weight that needs to be given to particular items or parts of language (Kennedy 1998). Moreover, interaction with authentic, analyzed texts has encouraged more inductive, student-centered approaches to learning such as data-driven learning (Chambers 2010).

In so far as ESP teaching is concerned, even a simple word count based on a specialized corpus can highlight the salient concepts, words and expressions that learners need to know in order to successfully handle texts in their subject area.

Flowerdew, as early as 1993, provided an example of how a corpus of biology readings and lectures can help teachers make informed choices on item and text selection. Coxhead (2000) using a corpus of academic texts proposed a list containing those vocabulary items which are the most relevant and useful for EAP learners, inaugurating a series of such similar lists in a number of different domains (Chen et al. 2009; Chen & Ge 2007; Gilmore & Millar 2018; Huang 2007; Liu & Han 2015; Martinez et al. 2009; Yang 2015). Kübler & Foucou (2003) used bilingual corpora in ESP teaching, focusing on the difficulty that French learners have to learn verbs in the computer domain. Mudraya (2006) highlighted the cases of terms resulting from semantic drift and suggested ways to help students distinguish their specialized from their general usage. Finally, corpus consultation has been extensively used from a genre-based perspective (Bhatia et al. 2004; Noguchi 2004; Weber 2001) to help students identify lexico-grammatical as well as non-lexical features of a particular genre. Additionally, genre-based studies have been carried out to help students with

writing tasks, e.g. writing research articles in the computing domain (Chang & Kuo 2011) or psychology (Bianchi & Pazzaglia 2007).

3 Tools for corpus compilation and lexical analysis software: The sketch engine

The sketch engine is a corpus manager software which constitutes a complete toolkit for corpus analysis (Kilgarriff et al. 2004). It includes a number of the most well known corpora in General English, among them being the British National Corpus, London English Corpus, British Academic Written English Corpus, etc. along with specialized corpora such as The British Law corpus, Science corpus etc. Most importantly, it provides you with the facility to create your own corpus using the WebBootCat facility (Baroni & Bernadini 2004).

Additionally, it provides a complete set of lexical analysis tools such as the Word List, the Concordance, the Wordsketch, the Word-sketch Difference, the Distributional Thesaurus and the Term list which provide us with the means for a comprehensive and exhaustive treatment of texts constituting the ultimate answer to the corpus linguist's needs.

4 Corpus construction

On account of the fact, that there weren't any suitable corpora in the Sketch Engine selection to study printmaking terminology, the WebBootCat tool was used to construct corpora from the Web. The methodology followed comprised the following stages:

1st stage: A preliminary collection of terms was compiled drawing material from personal course notes[1]. These terms were used as seeds in the WebBootCat facility to extract relevant web pages.

[1] I have been teaching printmaking terminology in the Plastic Arts and Sciences of Art Department in the University of Ioannina since 2002.

2nd stage: The term list tool was used to yield a more extended list of terms from the web pages. These terms were used as new seeds for the extraction of more web pages.

3rd stage: The term list was enriched by the terms found in the glossaries of three art books. The art books mentioned are The Artist's Handbook of Materials and Techniques (Mayer 1991), The Artist's Handbook (Ray 1987) and Artforms (Preble et al. 1999). The term list tool was run again to provide even more web pages.

4th stage: The retrieved files were checked to prune away irrelevant web pages.

5th stage: Once this step was completed the next step involved the checking of copyright permissions. Thus, only files free from copyright constraints were included in the corpus. At the end of the process, the corpus numbered 61331 words.

6th stage: Once the corpus was compiled, the term list tool was used again to extract lists of candidate terms. These lists were then checked for termhood. The final term list consisted of 76 single word terms and 64 compound terms.

The resulting terms in the term lists constituted the puzzle pieces that would be later used to construct the ontology (the puzzle) exploiting corpus information.

5 Corpus analysis method

Still, the number of 140 terms was too high to start. Therefore some inside information was needed as to which are the most frequent terms, them usually being the most salient.

At this stage, the **word list tool** was used, offering a sample of average frequency words, as, in accordance with what is commonly believed in terminology and information retrieval studies (Lauriston 1996; Zipf 1949), content bearing words which designate important concepts are present at average frequencies. On the other hand, very frequent words are usually function words while very low frequency words enjoy an accidental occurrence. In the table below, we can see a sample of the mid

frequency words in our corpus as very frequent words and very infrequent words have been excluded (terms appear in bold).

Word	**Frequency**	**Word**	**Frequency**	**Word**	**Frequency**
paper	311	In	163	method	116
Used	304	**acid**	162	Also	116
from	302	made	156	**printmaking**	116
was	288	into	156	**drawing**	113
an	288	but	156	century	109
can	273	**lines**	153	Other	108
print	269	A	149	Were	106
ink	263	Will	148	One	104
printing	257	**engraving**	147	**Woodcut**	103
which	237	metal	146	art	102
etching	236	more	141	such	102
surface	229	**artist**	139	using	101
image	204	has	136	**plates**	101
prints	194	This	131	first	99
ground	188	areas	130	through	97
not	187	technique	127	its	97
This	176	printed	126	use	96
then	173	at	123	wood	93
this	167	have	119	**intaglio**	93
process	165	**line**	118	**block**	91

Table 1. Mid frequency words in the printmaking corpus

Having established the most important content bearing words in terms of their frequency in the corpus, we proceed by studying their behavior in context. To achieve that, we use the **concordance tool**. The concordance tool can provide context information for a given wordform, term, lemma or tag. For each such key word in context, the whole sentence is presented together with information concerning the file from which this sentence was extracted.

Studying the word or term in context, one can study its collocational behavior as well as the relations it holds to other important words or terms in the text. This is a crucial step for constructing the final ontology. Let us look at some collocations for the term *intaglio***.** Intaglio is the second major method in printmaking[2].

Concordances with intaglio

*In **intaglio** printmaking, the artist makes marks on the plate (in the case of aquatint, a copper or zinc plate) that are capable of holding ink.*
*In **intaglio printing**, the lines to be printed are cut into a metal plate by means either of a cutting tool called a burin , held in the hand –in which case the process is called engraving; or through the corrosive action of acid –in which case the process is known as etching.*
***Intaglio engravings** are made by carving into a plate of a hard substance such as copper, zinc, steel, or plastic.*
*To take an impression from an **intaglio plate**, (…) the artist scratches lines directly on the plate with a sharp instrument such as a needle or a knifepoint. The process of scratching the plate displaces metal and creates a rough burr of metal along the edges of each line.*
The design is cut, scratched, or etched into the printing surface or plate which can be copper, zinc, aluminum, magnesium, plastic, or even coated paper.
***Intaglio: intaglio prints** include any process in which ink is transferred from depressions in a plate to the printed surface. This category includes etchings, aquatints, engravings, drypoints, mezzotints and more.*

In the above concordances, right from the first sentence we can see a definition of the term. *Intaglio* is a printmaking technique in which an *artist* makes *marks* on a *plate*. These marks hold *ink*. The second sentence mentions the two major techniques employed in the *intaglio method*. In the former a sharp tool like a *burin* is used to cut lines into the *plate*, while in the latter the artist uses *acid* to *bite lines* on the surface of the plate. In the third sentence, we learn that such plates can be made of zinc, copper

[2] The word comes from the Italian word **intagliare** which means to *cut/carve into*. As the name reveals, in the intaglio method, the image is incised or bitten with a sharp tool or acid into the surface of a metal plate. Then, only the recessed areas are inked and finally, the plate with the piece of paper on top is passed through a press. This way, the image is transferred onto the paper and the final print is produced.

or steel while in the fourth that a *needle* can also be used to leave marks on the plate. The type of the line that such a needle leaves is known as *burr*. Finally, the last sentence mentions all intaglio methods. Furthermore, from the above examples we can derive the key verbs that are being used in this technique such as *cut, engrave, carve, etch* and *scratch.*

Such information is invaluable and can be used per se[3] or as an intermediate step to help us construct our final ontology.

6 The creation of an ontology

Before presenting the methodology of constructing an ontology, one needs to explain what is an ontology. There are numerous definitions of the ontology as a concept, dating as early as Aristotle who divided the world into 10 broad categories of concepts e.g. physical objects, quantity, quality, relation, time, place, position, etc. to the modern use of the word ontology which is a term used in a much looser sense (McGuinness 2002) including artefacts such as taxonomies, thesauri, semantic lexica etc. A commonly cited definition is given by Gruber (1993), namely that Ontology is the formal[4] explicit specification of conceptualization. By conceptualization, we mean an abstract view of a domain with the concepts that exist in a particular area of knowledge together with their properties and interrelationships.

Alongside the numerous definitions, equally numerous are the methodologies followed in ontology construction. The one followed here is a revised version (steps 1 and 2 have been omitted) of the one described in the 101 Method Guide (Noy & McGuiness 2001) and involves the following steps:

[3] Material drawn from the concordances can be used to construct gap filling exercises, multiple choice exercises and matching exercises which involve the key terms in the domain; the latter could be verbs, nouns or adjectives.

[4] It is in the word formal that the main difference lies between ontologies on one hand and mind maps, concept maps and similar artefacts on the other. With the latter, one can freely add new concepts and relations without much concern as to whether they clash with existing concepts and relations. With ontologies, however, formal mathematics is used to define terms so that definitions of concepts can be machine-interpretable/understandable and thus searched and reasoned about by computer programs. Therefore, concepts together with their properties and relations must be specified in a formal, rigid way that does not allow for conceptual inconsistencies.

Step 1_Glossary development: To start with, all the terms which make up the conceptual framework of the domain were collected. As has already been mentioned, in this research, terms were derived from:

- Personal notes
- Art book glossaries
- Terms extracted from the artcorpus using the term list tool

Step 2_Conceptualisation: At this stage, terms were assigned to concepts. One major decision concerned the subdivision of terms to concepts expressing classes (objects), properties or relations. Intuitively, nouns correspond to classes, adjectives to properties and verbs to relations. Additionally, nouns can correspond to instances, e.g. 'Jan Van Eyck' is an instance of the class **painter.**

Step 3_Defining the classes and the class hierarchy: Once the terms have been assigned to concepts, these concepts have to be defined and then structured hierarchically. In this work, the combination approach has been followed, in which we firstly define the most salient concepts and then we generalize or specialize them. According to Rosch (1978), this is the easiest way to proceed as middle-level concepts are the most descriptive concepts in the domain. To help conceptualize the domain, the MindJet tool[5] was used.

Step 4:_Defining properties (Describing the internal structure of concepts): According to the 101 Method Guide (Noy & McGuiness 2001) properties can be

- **Intrinsic:** e.g. colour of a painting material
- **Extrinsic:** e.g. brandname of a certain paint
- **Parts:** e.g. the part of a certain tool
- **Relationships:** e.g. which tools are used in which technique

To extract the major properties for each concept as well as establish the relations they hold to other important concepts in the domain, the concordances extracted by the concordance tool were consulted.

[5] https://www.**mindjet**.com

Thus, links between concepts of a different nature than those expressed by synonymy, antonymy or hypernymy/ hyponymy were established, e.g. *has-support surface, uses, has-part, cuts, can be inserted in, is made of* etc.

Step 5_Implementation: For the implementation of the ontology, Protégé was used, the most popular among ontology development tools that helps create, edit and manage ontologies.

Figure 3 shows a small ontology created using the Protégé interface. The ontology concerns the ontological relationships holding between the term *intaglio* and the rest of the concepts in the printmaking terminology. The Ontograph plugin[6] allows the ontology to be viewed graphically.

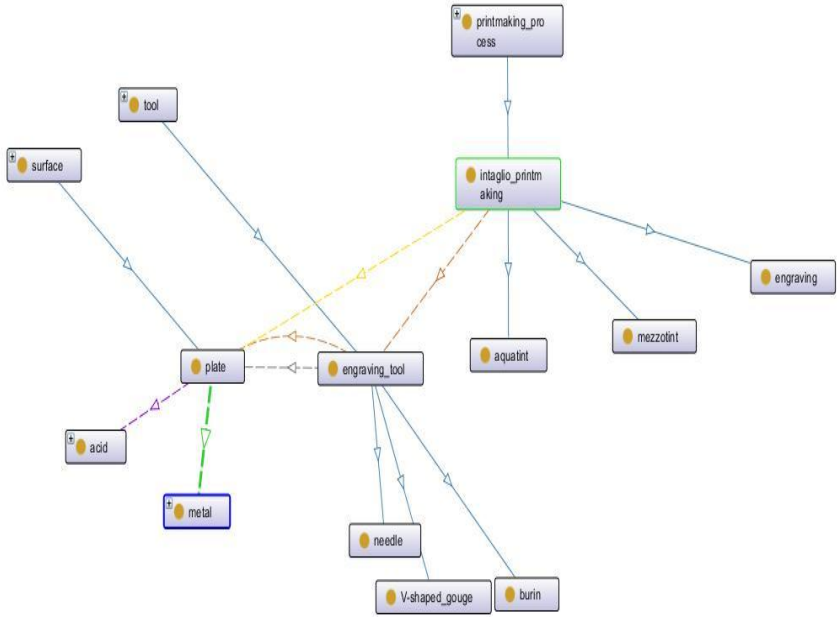

Figure 1. The Intaglio printmaking ontology

In the above figure, we can see that *Intaglio printmaking* is a kind of *Printmaking process* which *Includes Aquatint, Mezzotint* and *Engraving*. It *Uses* an *Engraving tool* (a child of *Tool*) which can be a *Needle,* a *Burin* or a *V-shaped gouge*.

Moreover, it *Has* a *Plate* (a child of *Surface*) as a support surface which *is made of Metal***.** This *Plate can be inserted* in *Acid*.

[6] http://protege.stanford.edu

Finally, we can see that there are two lines connecting the concepts *Engraving tool* and *Plate.* The first corresponds to the object property *cuts* and the other to the object property *incises*.

These two are synonym concepts and can be used alternatively by the teacher as it suits him/her. We can see that the links joining the two concepts are of a different colour. This is happening to indicate a different kind of relationship between the two concepts. If one clicks on the link, the name of the relationship between the two concepts appears.

7 Applications in classroom

Having constructed the printmaking ontology in cooperation with a subject specialist, the ESP teacher can start introducing his students to the most important concepts in a specific field. Taking the printmaking ontology as an example, the most salient concept in the printmaking ontology is the term *printmaking*. In our corpus, printmaking occurs 145 times.

As the concordances are many, they offer an excellent opportunity for team work. Thus students can be divided into groups, each group having the task to study 10 to 20 concordances. On the basis of the concordances, they can construct mind maps or concept maps[7], using Cmap tools[8] or another free tool for creating mind and concept maps. The Cmap tool in particular provides the facility for working jointly on mind maps, allowing users to share them on the Cmap cloud anywhere on the Internet as well as link multimedia resources to their mind maps. As a result joint projects can be carried out within class, across institutes within the same country or across institutes situated in different countries promoting cooperation and inter-cultural awareness.

[7] The use of concepts and mind maps in teaching was based on the learning psychology of David Ausubel (1963, 1968; Ausubel et al. 1978). The fundamental idea in Ausubel's cognitive psychology is that learning takes place by the *assimilation* of new concepts and propositions into existing concept and propositional frameworks held by the learner. Thus concept maps, mind maps, brain maps, semantic frameworks, frames as well as other conceptual structures (Coulon 1997; Jonassen 1998; Sowa 1984) have proved to be a powerful tool of the Cognitive constructivist theory of Meaningful Learning.

[8] http://cmap.ihmc.us/

Next students will be asked to merge their mind maps pruning away repetitive information to form the ontology for the specific concept.

Throughout the process, the teacher could give hints to his students as to what they should be looking for or leave them to explore it on their own. For instance, in the case of the printmaking term, the teacher could ask the students to look into the concordances for information either of conceptual or linguistic nature, namely:

- The different methods used in that form of art
- The tools employed
- The techniques employed in each method
- The language used in definitions of concepts
- The language used in classification of concepts
- The kind of compounds printmaking participates in
- The words that collocate with printmaking on the left and on the right when it exists per se.

The whole procedure is succinctly captured in the following figure:

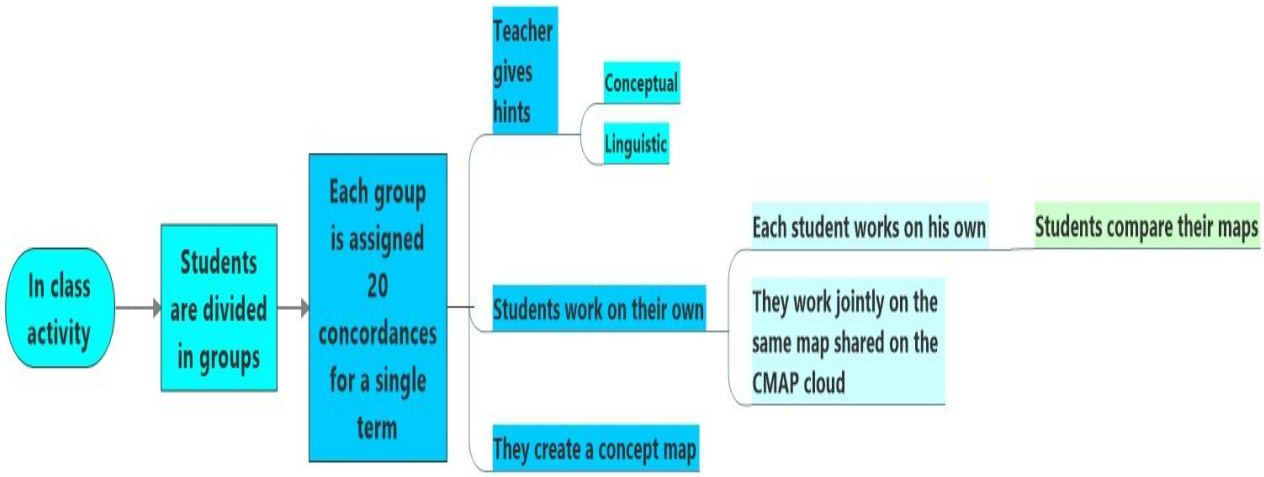

Figure 2. Educational activity

The concordances together with the resulting mind map can be seen right below:

The concordance set and the mindmap for printmaking

- In *intaglio printmaking*, the *artist* makes marks on the *plate* (in the case of *aquatint*, a *copper* or *zinc plate*) that are capable of holding *ink*.
- Major *techniques of printmaking*. The techniques of printmaking are divided into three major processes: *relief*, *intaglio*, *surface*. The *surface processes* are subdivided into two categories: *planographic (lithography)* and *stencil methods*. The methods are often combined. In *relief processes*, the *negative*, or nonprinting part of the *block* or *plate*, is either *cut* or *etched away*, leaving the design standing *in relief*.
- *Engraving* for the purpose of *printmaking* creates plates for intaglio printing. *Intaglio engravings* are made by *carving* into a plate of a hard substance such as *copper*, *zinc*, *steel*, or *plastic*.
- *Mezzotint* is a *printmaking process* of the intaglio family, technically a drypoint method. [1] It was the first *tonal method* to be used, enabling half-tones to be produced without using line- or dot-based techniques like *hatching*, *cross-hatching or stipple*. Mezzotint achieves tonality by roughening the plate with thousands of little dots made by a metal tool with small teeth, called a "*rocker*."
- *Printmaking* (other than monotyping) is not chosen (…) Common types of matrices include: *metal plates, usually copper or zinc, or polymer plates for engraving or etching; stone, aluminum, or polymer for lithography; blocks of wood for woodcuts and wood engravings; and linoleum for linocuts. Screens made of silk or synthetic fabrics are used for the screenprinting process.*
- The *linocut* is a *printmaking technique* similar to that of the *woodcut*, the difference being that the image is *engraved* on *linoleum* instead of *wood*.
- *Woodcut* is a *relief printing technique* in *printmaking*. An artist *carves* an image into the surface of a *block* of wood –typically with *gouges*.
- Drypoint is a printmaking technique of the *intaglio family*, in which an image is *incised* into a plate (or "matrix") with a *hard-pointed "needle" of sharp metal* or *diamond point*. Traditionally the *plate* was *copper*, but now *acetate*, *zinc*, or *plexiglas* are also commonly used. Like *etching*, *drypoint* is easier for an artist trained in drawing to master than *engraving*, as the technique of using the needle is closer to using a pencil than the *engraver's burin*.

- In *etching*, for example, the plate is covered in a *resin ground* or an *acid-resistant wax material*. Using an *etching needle*, or a similar tool, the image is *engraved* into the *ground*, revealing the plate underneath. The plate is then dipped into *acid*. The *acid bites* into the surface of the plate where it was exposed. Biting is a printmaking term to describe the acid's etching, or incising, of the image. [5] After the plate is sufficiently bitten, the plate is removed from the *acid bath*, and the *ground* is removed to prepare

Studying the above concordances, students can make the following observations:

Printmaking can be subdivided into the following techniques: *Relief printmaking, intaglio printmaking, planographic techniques, stencil printmaking* etc. Additionally, students can extract information concerning the tools that are used in printmaking, e.g. a *rocker, a needle, a burin, a gouge or generally a sharp tool.* Alternatively, in *intaglio processes,* such as *etching*, *acid* can be used to *bite lines* onto the *plate*.

Moreover, the support surface is a *matrix*; a *plate* in *intaglio techniques*, occasionally made of *zinc* or *copper*, or a *block* in *relief printmaking* made of *wood or linoleum*. Such a matrix can be *cut away, carved, incised, engraved* using a sharp tool or *etched* and *bitten* if inserted into *acid*. The effects produced after such processes on the support surface are *lines, marks* and *dots*. To have such effects more clearly marked, the plate can be coated with *acid-resistant wax* or *resin ground*. Finally, information on the major tonal techniques is given, the latter being *hatching, crosshatching* or *stipple*.

Some of the above information can be succinctly presented in the following mind map.

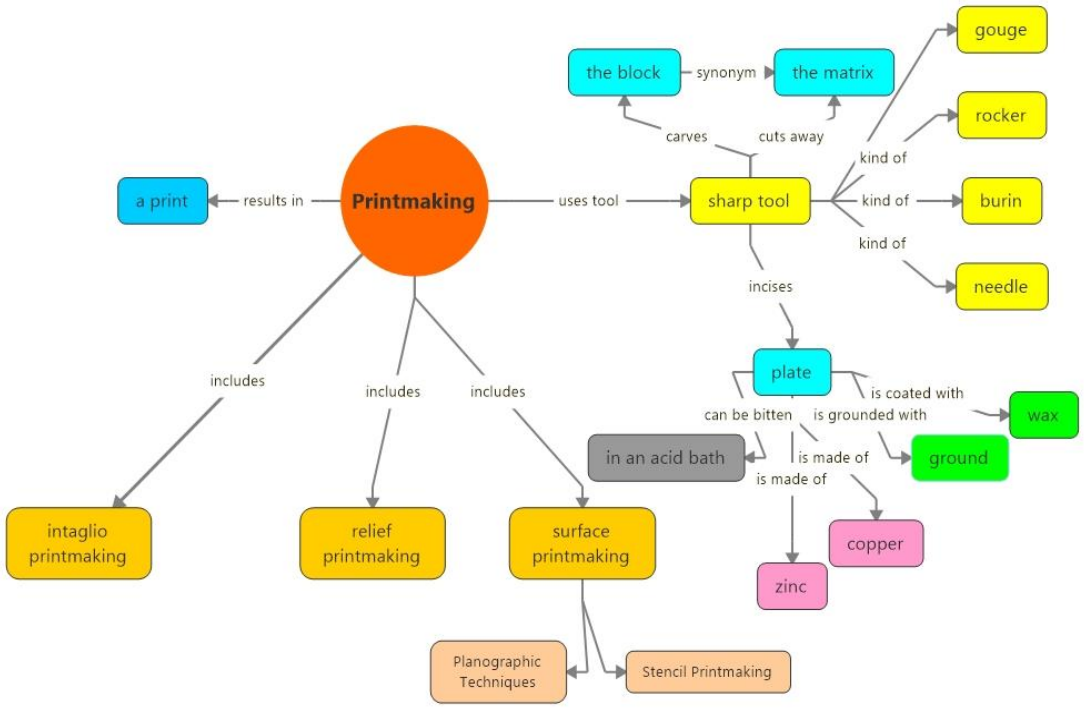

Figure 3. The printmaking concept map created from the concordance set for the term 'printmaking'

The educational value of the above activity can be enhanced if students are asked to combine the above conceptual artifact with WordNet. WordNet (Miller et al. 1990) is a semantic lexicon in which word senses are organized into semantic nets by means of semantic relationships such as hyperonymy, hyponymy and antonymy.

Thus for each word sense, travelling up or down the hierarchical tree, we can immediately find its direct or less direct hypernyms and hyponyms. In this way, we can create maps of gradable learning difficulty. For instance, in the above map the word *incise* can be replaced by a hypernym which is more common and can be more easily remembered by students, which is the word *cut*, or the expression *makes marks*. Similarly, if a student finds it difficult to remember the exact term *burin***,** the teacher or he himself can replace it with its broader semantic category which is a *sharp tool*. As a result, the teacher or students themselves can create mind maps of varying difficulty aiming at the language level required.

8 Conclusions

Concluding, the combined approach of using both corpus analysis and an ontology, in ESP teaching, can prove invaluable for the ESP teacher who by default is not a specialist for the following reasons:

- The ontology indicates the major concepts in the given field that need to be included in the teaching syllabus and how they are related.
- The hierarchical structure of the ontology offers him a stratification of knowledge and helps him decide on the preferred level of specialization.
- Next, the corpus analysis allows him to see how these concepts and their interrelations are linguistically realized.
- Concordances can provide rich material for gap filling and matching exercises, while the ontology can provide us with instant mind maps of different learning level material to be used either at the formative or at the summative assessment process.
- Such material can provide food for all sorts of classroom exercises, gap filling, matching exercises, mind maps, writing exercises etc.
- Finally, mind maps can be combined with a semantic lexicon such as WordNet to allow the teacher to scale up or down his teaching material according to his learners' knowledge level of English.

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