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CMAPTOOLS AND ITS USE IN EDUCATION

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Abstract. *Research to date acknowledges the efficiency of concept maps as a pedagogy to facilitate meaningful learning, yet in this digital era, there has been a growing interest in computer-supported concept map building and its educational benefits. IHMC CmapTools is a software tool that empowers users to build their knowledge using concept maps, to share and to publish them. The aim of this investigation is to report the results of the analysis of the use of CmapTools as a potential pedagogical approach for teaching and learning in different educational contexts, including the studies of English for Specific Purposes (ESP) at the university.*

The relevant literature used for this investigation was identified by searching several multidisciplinary and subject-related online databases. To this end, 23 selected publications have been analysed. The present investigation discusses the concept, the features and theoretical underpinnings of CmapTools, as well as reports on the research regarding its educational value and use in different educational contexts, including ESP studies at the university.

Key words*: CmapTools, computer-supported concept mapping, educational Web 2.0 technologies, English for Specific Purposes (ESP).*

1. INTRODUCTION

Research to date supports the efficiency of concept maps as a pedagogy to facilitate meaningful learning (Novak and Cañas 2006, 2008; Daley 2010; Dias 2010, 2011; Tajeddin and Tabatabaei 2016), yet in this digital era, a growing number of researchers is investigating computer-supported concept map building. "The traditional way of constructing concept maps uses paper-and-pencils; however, with the rapid development of information and communication technology, a number of computer-based concept mapping systems and software are made available" (Abdul-Majeed 2015, p.6). To illustrate, Tajeddin and Tabatabai (2016) describe five computerized concept mapping software tools, including *Inspiration, EDGE Diagrammer, SemNet, Learning Tool* and *IHMC Cmap Tools.* In another example, Ng (2015) distinguishes two commercial *Web 2.0* concept mapping tools, such as *Inspiration* and *Kidinspiration* as well as three free open access tools, including *Visual Understanding Environment (VUE), Mind42* and *CmapTools*, whereas Martınez *et al* (2013) present *CmapTools, Inspiration, SmartIdeas, DEMCO and MACOSOFT.*

The literature demonstrates that *Web 2.0* collaborative knowledge-building tools, including *CmapTools* have been widely investigated for about 15 years. However, even

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though the use of *CmapTools* in different educational contexts and its educational benefits have been discussed by a number of foreign researchers, in Lithuania it has not been researched yet. Thus, this investigation aimed to analyse the educational *Web 2.0* technology *CmapTools* as a potential pedagogical approach for teaching and learning in different educational contexts, including the studies of *English for Specific Purposes (ESP)* at the university. To this end, the present research analyses the concept of *CmapTools*, establishes its category within the latest typology of educational technologies, describes the characteristics and theoretical framework supporting the application of *CmapTools*, and reports on the results of the application of *CmapTools* in different educational contexts, including its use for teaching and learning *ESP* at the university.

2. The Research Method

The relevant literature used for this investigation was identified by searching four multidisciplinary and subject-related online databases, i.e. *SCOPUS, EBSCOhost, JSTOR* and *ERIC*. The literature overview was conducted to define the concept of *CmapTools*, establish its type in line with the existing classifications of *Web 2.0* technologies and gain an insight into its application both for teaching and learning in different educational contexts as well as for *ESP* studies at the university. Research works published in the period of 2004-2016 were retrieved using the search string *CmapTools, computer-supported concept mapping, English for Specific Purposes (ESP), technology-enhanced foreign language learning*. Thus, 23 studies were selected and analysed, which provided valuable insights into the concept and theoretical underpinnings of *CmapTools*, as well as into the results of the research conducted on *CmapTools* as a potential pedagogical approach for teaching and learning in different educational contexts, including teaching and learning *ESP*. To analyse the features, modality and theories supporting the application of the tool in various educational contexts, research papers published by the tool designers Joseph Novak and Alberto Cañas (*The Origins of the Concept Mapping Tool and the Continuing Evolution of the Tool*, 2006 and *The Theory Underlying Concept Maps and How to Construct and Use Them*, 2008) were also analysed.

2.1. The concept of *CmapTools* and its place within the classifications of Web 2.0 Technologies

CmapTools (http://cmap.ihmc.us/) freeware tool was created as the result of the research conducted by American scientists Joseph Novak and Alberto Cañas. Initially, *CmapTools*, which "came to life around year 2000 and picked up speed in the educational sector a couple of years later" (Frisendal 2012:123), was defined as a software environment that empowers users, individually or collaboratively, to represent their knowledge using concept maps, to share them with peers and colleagues, and to publish them (Cañas *et al* 2004:1). Two years later, the authors stressed that it is "a client-server software tool to facilitate the construction and sharing of concept maps" (Novak and Cañas 2006:180). The definitions that were later provided by other researchers are in line with that of Cañas *et al* (2004). For instance, Frisendal stated that it is "the tool we use for drawing concept maps" (2012:123) and Drapper (2015: 221) defined it as "a concept-map learning environment that enables students individually or collaboratively to visually represent their knowledge". Thus, *CmapTools* is defined by these researchers as either a tool or an environment both terms

being used interchangeably, which differs from the definitions provided by Fuggetta (1993) in the classification of computer-aided software engineering technology. According to Fuggetta (1993), such technology falls into three categories: *tools* that support specific activities in the software life-cycle, *workbenche*s that combine two or more tools focused on a specific part of the software life-cycle and *environments* that include two or more tools or workbenches and support the complete software life-cycle. On the other hand, in this context it is important that the boundaries between these categories are blurred (Sommerville, 2008), which may explain the synonymous usage of the two terms.

Ambiguities in conceptualizing the tool have also been observed while attempting to establish its place within the typologies of educational technologies. To illustrate, the latest and presumably the most exhaustive typology of *Web 2.0* educational technologies proposed by Bower (2015) presents 212 current *Web 2.0* technologies suitable for teaching and learning purposes that are grouped into 37 types and arranged in 14 clusters (https://net.educause.edu/ir/library/pdf/csd6280.pdf). The analysis of the typology revealed that *CmapTools* has not been attributed to any of its types or included in any of its clusters, even though it is considered to be a well-known educational tool. For example, Ng (2015) points out that it "is used worldwide in all domains of knowledge and by users of all ages to graphically express their understanding. In particular *CmapTools* is used in schools, universities, government organizations, corporations and small companies and other organizations both individually and in groups, for education, training, knowledge management, brainstorming and information organization" (Ng 2015:115). The author of the typology states that not all *Web 2.0* technologies were incorporated in his review leaving scope and "considerable potential to investigate how the various affordances of different *Web 2.0* tools with their different modalities and structures can be incorporated into learning designs" (Bower 2015:12). On the other hand, the analysis of a number of publications (Balula *et al* 2014; Martınez *et al* 2014; Sierra Flores Dona and Carrasco 2010; Dias 2010, 2011) reporting on the results of the application of *CmapTools* in different educational settings as well as sources of guidance on the *YouTube* (*https://www.youtube.com/results?q=Cmap+Tools+tutorial*) showed that this tool is much more widely used in Spanish and Portuguese speaking countries than in the rest part of the world.

The analysis of the existing typologies of *Web.2.0* educational technologies (Bower 2015; Orehovački *et al* 2012; Crook *et al* 2008) revealed that first and foremost they are based on the primary functionality of the tool: texting, image, audio or video sharing, multimodal production, digital storytelling, website creation, knowledge organization, data analysis, etc. As far as *CmapTools* is concerned, it does not meet the requirements for text, audio or video-based tools as it is primarily focused on graphical representation of users' knowledge and their conceptual understanding. Therefore, it can be attributed to the cluster of graphical or image-based technologies which nest such umbrella terms as *Diagramming* and *Mind-mapping* (Bower 2015). Bower (2015) states that "mind mapping tools support the development of images to represent interrelated concepts in the form of a visual knowledge network that can be shared via *URL*. This can be used to represent conceptual and even metacognitive understanding" (Bower 2015:4). Even though the latter definition may imply that the concepts of both mind and concept mapping tools can be understood as being interchangeable, Ng and Hanewald (2010 2015) argue that mind maps and concept maps are two different visualization tools. The former "tend to start with a central theme with other ideas radiating (branches) from it, generating elements without the immediacy of having to establish an intrinsic conceptual framework" (Ng and Hanewald 2010; Ng

2015:115), whereas the latter allow for a clear networked structure with linking words and directional arrows.

The basic procedure of any concept mapping is "to name concepts, usually represented by rectangles or circles, and then draw lines with labels that describe the relationships between the concepts" (Novak and Cañas 2006:177). With *CmapTools* software you "… create nodes and connecting lines by simply clicking and dragging. Nodes can have labels, images, roll-over notes, and hyperlinks. These meaningful connections between concepts are called "propositions". Concept maps generally take a hierarchical shape, but "cross-links" that are made across the hierarchy are signs of creativity and more sophisticated understanding" (Colosimo and Fitzgibbons 2012:2). Novak and Cañas state that "hierarchical structure for a particular domain of knowledge depends on the context in which that knowledge is being applied or considered" (Novak and Cañas 2008:28) and recommend to construct concept maps with reference to some particular question we seek to answer, which they call a *focus question*. According to them, "the concept map may pertain to some situation or event that we are trying to understand through the organization of knowledge in the form of a concept map, thus providing the context for the concept map" (Novak and Cañas 2008:28).

Hence, if *CmapTools* is to complement the existing typology of *Web 2.0* educational technologies, it could find its place in the category of *Image-Based Technologies* fitting a missing type of *Concept Mapping* to share shelter with both commercial and open source *Web 2.0* educational technologies such as *Inspiration*, *Visual Understanding Environment (VUE),* all designed to facilitate students' knowledge visualization and externalize it (Novak and Cañas 2008; Colosimo and Fitzgibbons 2012).

2.2. Key characteristics and theories supporting the use of *CmapTools*

The literature review reveals that among many other features *CmapTools* allows its users to "construct their *Cmaps* in their personal computer, share them on servers (*Cmap Servers*) anywhere on the Internet, link their *Cmaps* to other *Cmaps* on servers, automatically create web pages of their concept maps on servers, edit their maps synchronously (at the same time) with other users, on the Internet, an search the *Web* for information relevant to a concept map" (Florida Institute for Human and Machine Cognition, (http://cmap.ihmc.us/). Morton (https://uwaterloo.ca/centre-for-teaching-excellence/teaching-resources/teaching-tips/educational-technologies/all/concept-mapping-tools) distinguishes the following five key characteristics of *CmapTools*, which in our opinion best summarize the functionality of the tool:

1. It is a personal computer-based (PC-based) tool: a free program, compatible with *Windows, Macintosh, Linux,* and *Solaris*, can be downloaded and installed onto a PC.
2. Nodes and connecting lines are created by simply clicking and dragging. Nodes can have labels, images, roll-over notes, and hyperlinks.
3. Maps can be saved locally on a PC or uploaded to a *CmapTools* server so that they can be accessed from any location. Saving them on the *CmapTools* server also means that several people can collaborate on the concept map simultaneously.
4. Clusters of nodes can be "nested" so that they collapse into a single node until they are re-expanded.
5. Maps can be saved in *HTML* format so that they can be viewed as a web page, but in doing so some of the functionality of the map (e.g., the nesting capability) is

lost. To experience the map with its full functionality, other users need to have *CmapTools* installed onto their PCs.

Besides, as the designers of the tool claim, *CmapTools* provides a variety of features that make it possible for teachers to use concept maps for a variety of the tasks that students perform (Novak and Cañas 2008). They suggest that the tool can be applied by the students to research additional information on the issue they study, resulting in an improved cmap with associated references. It is important that the very process of generating a concept map can be recorded for later playback, in such a way providing support for the teacher. Besides, concept maps and linked resources can be displayed full-screen for oral presentations and, if necessary, two concept maps can be contrasted graphically, allowing teachers to compare the student's map to theirs for an initial assessment. In such a way, a concept map becomes an artifact around which different activities of the learning process are centered (Novak and Cañas 2008).

The literature overview demonstrates that the use of *CmapTools* can be analysed from different theoretical perspectives. Firstly, concept mapping is in line with cognitive constructivism which posits that meaningful learning occurs when learners integrate new information into their existing knowledge structures (Novak and Cañas 2006). In their extensive study on the use of concept maps in online environment, Daley *et al* (2007) state that "concept maps are based on Ausubel, Novak, and Hanessian's (1986) assimilation theory of learning. Within this theoretical framework, the learner shifts away from learning in a rote way and moves to learning in a more meaningful, connected manner. Rather than memorising information, the learner searches out the relationships among concepts and organizes a structure to the new knowledge that is unique to him or her" (2007:38). According to Ausubel (1992), the new structure is a cognitive pyramid-like structure in which the most general ideas occupy the apex of the pyramid and the more specific details subsume under them.

Concept mapping can be also investigated from the perspective of Vygotsky's socio-cultural theory of human learning, according to which learning is a social process which results in the origination of human intelligence in a society or culture (Dias 2011; Umunadi and Ololube 2015). To illustrate, Dias (2011) suggests that "the process of concept mapping can also be understood from a Vygotskian perspective, in that learning is a social process in which interactions among peers play an essential role" (2011: 901). The author states that concept mapping involves scaffolding and collaboration: "In the task of concept mapping, students are scaffolded by the interactions with peers as well as through the use of *CmapTools* software, ultimately enhancing learning. Both types of assistance will focus on experience during the process of reading, thinking, linking ideas, creating propositions and constructing text comprehensions" (2011: 901). This is also supported by Umunadi and Ololube (2015) who state that resting on Vygotsky's theory "… a teacher or more experienced peer provides the learner with "scaffolding" to support the learner's evolving understanding or knowledge domains or his or her development of complex skills. Collaborative learning, discourse, modelling and scaffolding are thus seen to support intellectual knowledge and skills of learners and facilitate intentional learning" (2015:142). The authors suggest that "*ICTs* can support this type of learning environment by providing tools for discourse, discussion, collaborative writing, and problem-solving, and by providing online support system to scaffold students evolving understanding and cognitive growth and development" (Umunadi and Olube 2015:142).

Thus, it can be stated that learning through *CmapTools* is in line with cognitive constructivist learning theories, such as Ausubel, Novak, and Hanessian's assimilation theory of learning and Vygotsky's socio-cultural theory of human learning.

2.3 Research on the application of *CmapTools* in different educational contexts

The research results reported in the literature support the efficacy of *CmapTools* for concept mapping in different educational contexts, including primary education, library settings, and higher education. For example, Vodovozov and Raud (2015) described how to employ the computer-supported concept mapping technology in engineering education in the field of electronics. They proved that computer-generated concept maps may have a variety of functions, including that of an educational thesaurus, a student's tool as well as an assessment tool to support instructors in promoting students' comprehension of the studying material and in improving their understanding of new concepts.

Colosimo and Fitzgibbons (2012) explored various applications for concept mapping in library settings based both on theory and practice, including the authors' successful use of the technique in their work. As some learners find additional motivation and inspiration for concept mapping when they use this software, the authors employed two kinds of online tools: *Inspiration* and *CmapTools.* According to them, "… in addition to being easy to learn, one of *CmapTools*' strengths is the depth of research that underlies its creation as well as the extensive documentation provided" (2012:10). The researchers established that computer-based concept mapping facilitated meaningful learning and active engagement in knowledge acquisition. They suggested that librarians can use concept mapping for a number of purposes, such as to help students articulate their information needs and assess their understanding, design courses and projects, organize personal and institutional knowledge, provide structure to collaborative activities, and organize electronic documents and resources.

Sierra Florres Dona and Carrasco (2010) investigated the use of *CmapTools* for teaching law, especially commercial and civil law. "The free and open access tool "*CmapTools*" has been chosen for students to develop, individually or collaboratively different "terms, concepts and relationships" involved in the subjects studied" (2010:6). The authors concluded that the subsequent realization of concept maps facilitated the construction of knowledge models and contributed to meaningful learning by simplifying the assimilation and understanding process of the issues involved in the subjects they taught.

Giombini (2004) described conceptual mapping as "… the most effective scientific tool to identify language acquisition processes, its conceptual development, and the instrumental abilities that ensure the comprehension of written texts for the whole life" (2004:1). For four years her team worked on designing and implementing an educational programme to continuously accompany children of different ages from formulation of concepts to the use of conceptual maps. She called *CmapTools* a writing system in practice operating as a narration system which ensures a complex communication, using several linguistic codes simultaneously.

Thus, the research proves that *CmapTools* is a valuable educational *Web 2.0* technology used in diverse educational contexts. Ng (2015) claims that concept-mapping as a pedagogy "… should be in every educator's repertoire of teaching strategies. It promotes higher order thinking in students and development of multiliteracies. Concept maps are multimodal learning artefacts where text, image, video and other visuals such as linking arrows and

different shaped boxes (for representing different perspectives of the topic), colour and positioning of keywords convey meaning according to the understanding of the creator" (2015:118).

2.4 *CmapTools* in ESP teaching and learning contexts

The use of *CmapTools* within the area of teaching and learning English as a second language for specific or academic purposes has been widely investigated (Abdul-Majeed Omar 2015; Balula *et al* 2014; Hunter 2013; Dias 2010, 2011; Liu *et al* 2010; etc.). To illustrate, Abdul-Majeed Omar (2015) analysed the impact of using a computer-based concept mapping technique on a group of pre-medical Saudi students' reading comprehension. The participants engaged in a 7-week long experiment used *CmapTools* software to generate concept maps. The research findings indicated that the use of computer-generated concept maps as a learning strategy had a positive impact on the students' reading comprehension.

The aim of the case study conducted by Balula *et al* (2014) was to find evidence of implementing a teaching and learning strategy based on the use of a collaborative concept mapping tool to improve their Portuguese students' reading and speaking skills in the contexts of business English. The study participants who were not proficient in English and often claimed not to know how to study English were asked to create and peer-review several concept maps using *CmapTools* during their Business English course. The results of the study revealed that the use of concept mapping supported by *CmapTools* promoted the development of their linguistic competences, including the use of business English terminology, as well as their communication and collaboration competences.

In another example, Hunter (2013) investigated *CmapTools* as a tool for teaching academic writing to English for academic purposes (*EAP*) learners who studied management. Based on a case study of efficient use of *CmapTools*, where *EAP* students discover intellectual leverage in argument mapping, the author stated that *CmapTools* justified its place among the essential tools for instructional discourse, especially in *EAP* settings where the identification of rhetorical orchestration is complicated and where it is difficult to directly encode learners' reasoning about dealing with a problem into the text.

Dias (2010, 2011), on the other hand, described phases and results of her action research born out of the need to develop her Brazilian undergraduate students' competence to read academic texts related to their field of study. Concept maps supported by *CmapTools* were chosen as a strategy to represent what they had read or understood after reading an authentic text. The study resulted in finding that students not only learned how to create maps by using *CmapTools*, but also enhanced their comprehension of English due to the new representations that were visually displayed in the concept maps as well as that they grasped the usefulness of cmapping for better reading comprehension, as "all the participants remarked that they were using the strategy for studying for other subjects of the curriculum and that they would go on using it" (2010:32).

Thus, it can be stated that the research on the use of *CmapTools* in *ESP* teaching and learning contexts has been basically concentrated on developing *ESP* students' reading strategies, which may be due to the fact that the *ESP* approach has always emphasized "… the development of print literacy and has used authentic texts mostly taken from the academic domain, such as abstracts, chapters of books, articles, diagrams, tables, maps" (Dias 2011:899).

3. CONCLUSION

The present investigation aimed to review the research literature on the educational *Web 2.0* technology *CmapTools* as a potential pedagogical approach for teaching and learning in different educational contexts, including the studies of *ESP* at the university. To this end, 23 selected publications were reviewed, providing us with the insight into its concept and theoretical underpinnings, as well as researchers' acknowledgement of its educational value and the potential to be used in diverse educational contexts, including university studies of *ESP*.

The research literature demonstrates that that freeware environment *CmapTools* which is defined as "a client-server software tool to facilitate the construction and sharing of concept maps" (Novak and Cañas 2006:180) has already been known and used for different educational purposes for around 15 years.

It has been established by the present research that although *CmapTools* technology has been defined as suitable for different educational environments (Novak and Cañas 2004; Frisendal 2012; Drapper 2015), it has not been attributed to the existing typologies of *Web 2.0* educational technologies (Bower 2015; Orehovački *et al* 2012; Crook *et al* 2008). According to the authors of the present investigation, as the primary functionality of *CmapTools* is graphical representation of users' knowledge and conceptual understanding, this allows to attribute it to the cluster of Image-based tools under a separate title of *Concept Mapping.*

The literature also demonstrates that cognitive constructivist learning theories, including Ausubel, Novak, and Hanessian's assimilation theory of learning and Vygotsky's socio-cultural theory of human learning serve as a theoretical framework of the use of *CmapTools* software in education.

The research findings indicate that *CmapTools* has been successfully used in a wide range of educational contexts, such as primary education, library settings, higher education, including engineering, law, *EFL* and *ESP* studies. It is worth mentioning that *CmapTools* has been used within the area of teaching and learning English as a second language for specific or academic purposes to develop *ESP* students' reading strategies, or as Ng (2015) resumes, to support students "where they need to understand the content in the text, identify the key concepts and show the interrelationships between them in a neat and coherent manner on a concept map" (2015: 116).

Thus, the findings of the present research lend support to the successful use of *CmapTools* as a potential pedagogical approach for teaching and learning in diverse educational contexts, including *ESP* studies at the university.

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