

TOWARDS AN INITIAL SEMIOTIC VIEW OF THE INTERACTIVE GRAPHIC ORGANISER

Mario J. Lopez, Hector R. Ponce

VirtuaLab, University of Santiago of Chile, Av. L B O'Higgins 3363, Santiago, Chile

mario.lopez@usach.cl, hector.ponce@usach.cl

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Abstract: This paper presents a first approach to understand a visual software application, named Interactive Graphic Organiser (IGO), from a semiotic point of view. The paper begins with the original conceptual background review, which came from both component software engineering and visual learning. The paper then moves to describe the technology and its impacts; the visual technology developed are IGOs, that allows cognitive skills development, and IGO based applications. Next and under the working hypothesis that the use of graphic organisers significantly improved involved cognitive skills, the paper describes some results from experimental research conducted to measure some of the visual technology's impacts. The paper concludes that, although initial treatment cannot claim to be comprehensive, it does provide a conceptual view and provides insight into the practices of those involved around IGOs and their applications.

1 INTRODUCTION

The core visual technology analysed in this paper is the Interactive Graphic Organiser (IGO) (Ponce, et al., 2008). This is a software application that combines non-linguist representations (shapes, symbols and arrows) with linguist elements (words and phrases) and a series of basic functions, which allows interactivity. IGOs so far have educational and business uses. In education, IGOs support the development and practice of cognitive skills for reading comprehension and writing (text production). In business, IGOs support the development and practice of higher order cognitive skills involved in business planning and strategy execution. Each IGO points to one specific cognitive skill. Combined IGOs make up larger applications for specific purposes.

This paper describes the conceptual background for the visual technology: component software engineering and visual learning. Next, it describes the visual technology as well as e-PELS, one of the larger applications built up with IGOs. The paper then presents some results of the technology impact on users. After that, the paper attempts to provide a first approach to look at the IGOs from the semiotic viewpoint. Finally, it presents a couple of remarks as a way of conclusions.

2 BACKGROUND

IGO's conceptual background comes from two sources, one from the ICT area (component software engineering) and the other from the educational area (visual learning).

2.1 Component software engineering

Interactive Graphic Organisers as a technology is based on software components. A number of components constitute each organiser and the integration of IGO components generates software applications with more functionality. A software component is a set of objects that carry out a specific function, specify interfaces and work independently from each other. Software components may include other components to make up more complex software systems (Laitkorpi and Jaaksi, 1999; Broy, et al., 1998). Software components major characteristics include composition (components integration to form larger granularity components); encapsulation (component works as a 'black box'); interoperability (components work independently and interact with other components); multi platform (components work independently from hardware and operating system); and self-contained (components

do not depend from other components to achieve their functions) (Crnkovic and Larsson 2002).

A software component construction essential aspect is the interface among components. The interface is the communication mechanism between two components, which allows interoperability. A software component has a 'provide interface' that declares the services provided and a 'require interface' that declares the required services to operate correctly. Another important aspect is software components composition that allows interconnecting components through their interfaces. There are three types of component composition: sequential (when an adapter is required to connect two incompatible components); hierarchical (when a component executes a service required by a compatible component); and additive (when two or more components make up a component of greater granularity) (Hall, 2007). The composition process is a class of client-server process. The client component requires a service offered by the server component interface. In its turn, the server component executes the required function and returns its results to the client.

2.2 Visual Learning

Visual learning takes into account that an important set of learning strategies requires mental representations that result in visual schemes for their understanding. For example, there are simple learning techniques paragraph underlining and margin notes, and other techniques that require complex cognitive processes, such as conceptual mapping.

The advantages of introducing strategies that require visual representation are diverse and based on the fact that about 80% of perceived information comes through the visual channel. A visual learning principle is that students, using visual tools, can clarify their thinking, enhance their understanding, integrate new knowledge and, additionally, identify misconceptions (Gardner, 2003). A visual scheme allows students to discover and design patterns, interrelationships and interdependencies, and provide opportunities to develop creative thinking (Lopez, et al., 2007). For example, through a differences and similarities diagram, students have a visual strategy that allows them to identify similarities and differences between two or more objects (Witherell and McMackin, 2005). This technique facilitates reading skills, develops diagramming abilities, and synthesis through structured analysis registration of similarities and

differences. Graphic organisers are typical representatives of visual learning. Graphic organisers encourage the development of structured activities; help to display content in a graphical form, and support the development of cognitive skills (Marzano, et al., 2001).

Graphic organisers, when use as thinking tools, facilitate the development of students' deep learning, discouraging a memory based or repetitive learning (Ausubel, 1963). Graphic organisers help to build substantive and non-arbitrary relationships between what it is already known and what it is to be learnt (Coll, 1991). Thus, a learning process is activated where new understandings take place by providing and generating meaningful experiences for learners. (Entwistle, 1981; Gibbs, 1999). Three requisites are required to accomplish this task. First, content logical significance; that is, content structure should facilitate how learners build relations between new and their previous knowledge. Second, psychological significance of content; related to the internal representation made by learners of logical significant of content. Third, learners' favourable attitude given by the disposition to substantively, profoundly and no literally relate their cognitive structure with the new material (Gibbs, 1999). The development of deep learning through the use of graphic organisers in educational environments depends upon the mediation between didactic (methods and strategies) and learning outcomes (Lopez and Ponce 2004). This requires a rigorous and systematic teaching and learning planning, including content and aims characteristics, learner starting level, methods, didactic sequences, and learning strategies to facilitate deep meaning of contents and activities. Basic cognitive operations such as observation, comparison, classification, analysis and synthesis are better developed when learning activities consciously put emphasis on their need to process content and create new knowledge (Amestoy, 2002).

Learning is a process in which "people generate from their experience the concepts, rules and principles that guide their behaviour in new situation" (Kolb, et al., 1991). Learning takes place through a continuous and recurrent sequence of actual experiences and, as experiences by themselves are insufficient, thought, observation, and abstract concept construction go along with experiences. Thus, it is suggested that an effective implementation of graphic organisers should follow the experiential learning process: (1) Concrete experiences followed by (2) observation and reflection of such experiences, which leads to the (3)

formation of abstract concepts and the constructions of principles or generalisations, followed by (4) the testing of such concepts in new situations.

3 VISUAL TECHNOLOGY

The following is a brief description of IGO and a software application developed using software components such as the IGOs.

3.1 Interactive Graphic Organisers

Interactive Graphic Organisers facilitate the discovery and design of patterns, relationships, and interrelationships, as well as helping to develop creative thinking. IGOs educational uses include (a) content visual presentation on its own (Ponce, et al., 2008) or as an add-in for PowerPoint (Lopez, et al., 2008). (b) Development of students' learning activities for either class work or homework. (c) Reading understanding allowing the reader-learner to make sense or meaning, before, during and after reading. (d) Writing producing allowing the writer-learner to order ideas before writing, paraphrase, write short tales and so on. IGOs business uses include (a) content visual presentation on its own or as an add-in for PowerPoint. (b) Developing companies' strategic plans. (c) Linking strategies to operations.

Each organiser has functionalities in a tool bar to create, edit, remove, store, retrieve and print what the user is developing or has completed. IGOs are highly interactive through adding and editing the graphic forms. The graphic organisers' features grant them a high degree of interactivity, allowing cognitive skills development and practice, as shown in Figures 1 and 2.

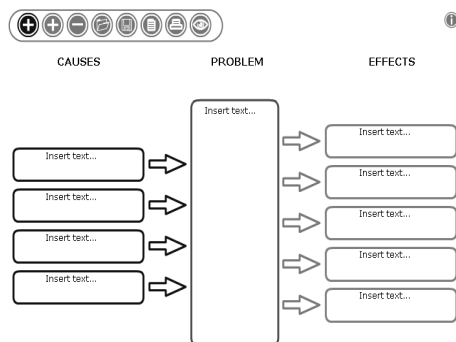


Figure 1. IGO Cause and Effect.

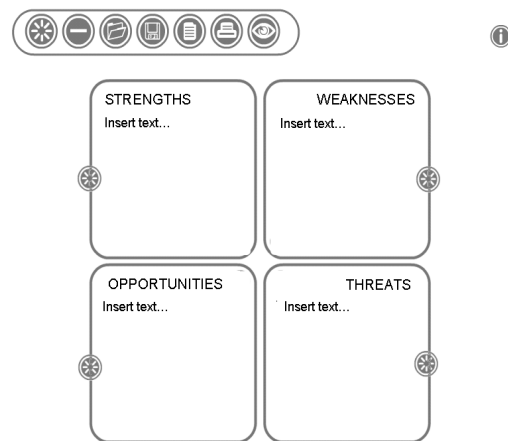


Figure 2. IGO Swot.

3.2 Software tools

Interactive Graphic Organisers are software components technology implemented in Adobe Flash (Sametinger, 1997, Gallardo, et al., 2009). This allows easy integration with other components and into Web environments and Flash compatible software. The application to describe is the component software (Szyperski 1998) virtual training programme in comprehensive reading (e-PELS, from its acronym in Spanish) (Ponce, et al., 2007a and 2007b). e-PELS design and development followed Roman (2004) and Roman and Gallegos (1994), who proposed a training programme in comprehensive reading based on a set of cognitive and meta-cognitive skills.

The basic cognitive processes identified are (1) information acquisition strategies, (2) information coding strategies, (3) information retrieval strategies, and (4) information processing support strategies. In his original proposal, Roman suggested the following strategies: underlining, paraphrasing, self-questioning, text structure and conceptual maps. The programme e-PELS expanded conceptual mapping to the use of interactive graphic organisers and added strategies for summarising and word meaning.

For the acquisition strategies, e-PELS includes underlining or colouring, to stand out relevant words or phrases, and paraphrasing, to allow students their own wording of texts. For the coding strategies, e-PELS incorporates the text structure strategy (problem solving, cause-effect, descriptive, comparison and time sequence), self questioning to relate and think about the text, and interactive graphic organisers for the organisation of ideas or arguments within the source text. For the retrieval strategy, e-PELS incorporates the summary for synthesising

the text. For the word meaning strategy, e-PELS includes the word box. e-PELS also includes other functionalities that are typical to this sort of software: new, open, save. As e-PELS is software component based, integration into other applications (flash or Web) is rather easy.

Figure 3 is an image of e-PELS in use. Each of the strategies is accessible from a tab: Highlight and paraphrase; text structure; graphic organisers, summary and word box.

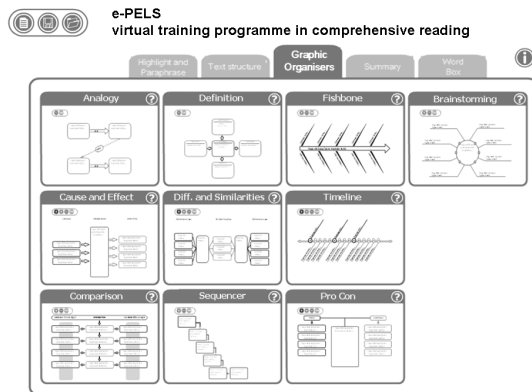


Figure 3: e-PELS in use

4 TECHNOLOGY IMPACTS

With the hypothesis that use of IGOs and e-PELS would have a positive effect on users, research designs followed the cuasi-experimental model, with control and experimental groups. IGOs evaluation was with a higher education group of students and e-PELS evaluation was with 18 primary schools.

4.1 IGOs impacts

The research was into an information systems design course, which belongs to the seventh level (out of twelve) of the Civil Industrial Engineering degree at the University of Santiago, Chile (Lopez, et al., 2009). 45 students, organised into 14 teams, on the course during a first university term constituted the experimental group. 35 students, organised into 9 teams, on the same course but taken on the previous university term constituted the control group. Therefore, different students constituted the experimental and control groups.

The experimental group participated in learning activities that integrated the IGO software. The experimental group used five IGOs in four different learning activities. Typically, learning activities included learning outcome identification; activity's

name and brief description; IGO(s) to be used (if appropriate), and systematic instructions for producing digital and physical evidence. The previous term, the control group did not use any IGOs to carry out the same learning activities.

The following is an example of the experiences with IGOs carried out by the students in the experimental group. In this example, the experimental (14 teams) and control (9 teams) groups were assessed for their ability to design logical components of their computer application prototype. Both groups had to design the logical components of an information system prototype. The experimental group made use of two Interactive Graphic Organisers for the assignment, while the control group did not use any graphic organisers.

The control group design ended to be both very intuitive and software applications disorderly listed. The experimental group had support from two Interactive Graphic Organisers. Initially from the Brainstorming IGO, this enabled them to list all necessary components that their prototype should have included. The complete list was then analysed, prioritized, and entered into the Sequencer IGO. Figure 4 shows the structure of the Interactive Graphic Organisers Brainstorming and figure 5 the IGO Sequencer.

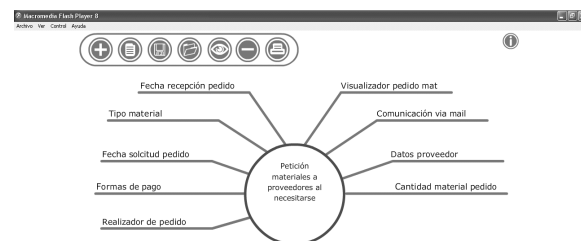


Figure 4. IGO Brainstorming.

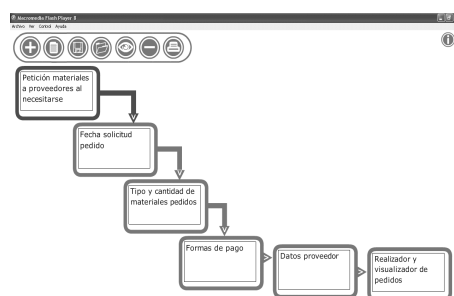


Figure 5. IGO Sequencer.

Equivalent assessment marks for experimental and control groups were compared through *t*-test

(when data was normally distributed) or *U* test (when data was not normally distributed). The data showed that the teams use of the Brainstorming and Sequencer IGOs had a significant impact for producing a programme pseudo coding ($U = 34.5$, $p\text{-value} = .037$, and $\alpha = .05$).

Qualitative data on students' perceptions of IGO uses showed that their most valued aspects were: (1) structural thinking and (2) keep focus on what matters. Regarding the first, students indicated that IGOs use helped them to not only think but also, and more importantly, to think more structurally, think with more sense, organise ideas more easily and synthesise more rapidly. Regarding the second, students considered that using the IGO software allowed them keeping focus on what mattered to the course: solve an information problem through an information system design and prototype.

4.2 e-PELS impacts

The following analysis comes from an experimental evaluation of e-PELS with 4th grade elementary students (Ponce, et al., to be published). It will be shown how the different visual learning strategies included in e-PELS were articulated to support a meaning construction process. This was carried out through a training programme that lasted 11 sessions of two-hours each for two months at the school's computer lab. Some examples are shown and the performance of the students on each strategy included in e-PELS. The following figures show a typical use of highlighting and paraphrasing strategies for the students in the experimental group.

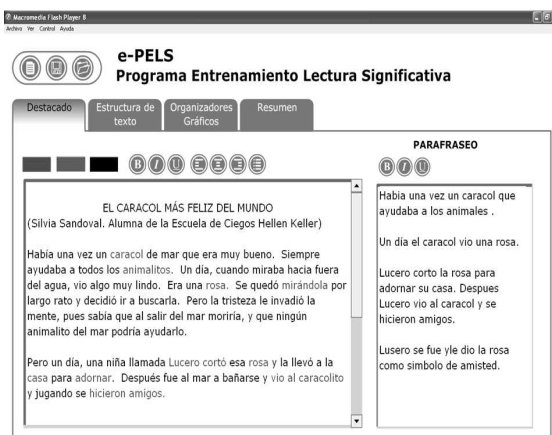


Figure 6. Highlighting and paraphrasing

The evidence demonstrated that at the beginning of the training programme, students in the experimental group did not know how to use the

highlighting strategy; they were not able to differentiate main ideas for a later understanding of the text. By the seventh training session, most students identified key words or phrases, without highlighting extensively. Regarding the paraphrasing strategy, the evaluation of the evidence demonstrated that at the end of the training process, the synthesis as a thinking skill was not completed developed in these students. However, they replaced it by constructing phrases that correctly articulate the elements of the source text. Student's ability to articulate more significant phrases increased as the sessions went by. The paraphrasing, initially seen as an end, it was soon transformed into a skill to produce small pieces of text increasingly personalized and significant.

Figures 7 and 8 show an exemplary use of text structure strategy and interactive graphic organiser, respectively.

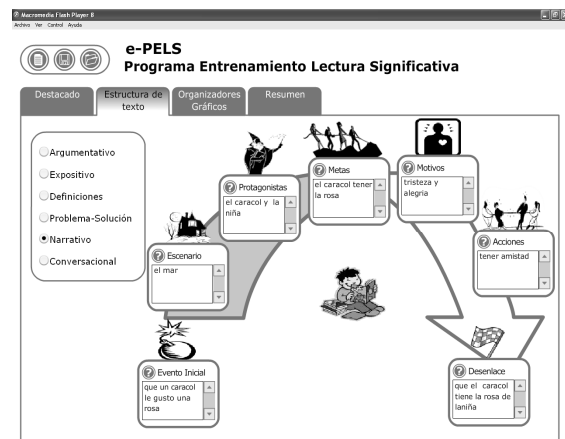


Figure 7. Use of text structure and self-questioning.

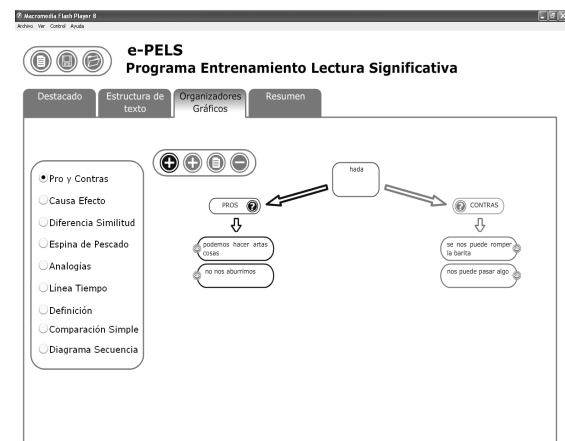


Figure 8. Use interactive graphic organiser.

For the use of text and self-questioning, the evidence shows that students increasingly

understood the explicit text elements. At the beginning of the training process, students showed a superficial comprehension of the reading challenges present in their training. As the students continued in their training, they were able to explore, process, repeat and maintain the reading's original sense. Text structure and self-questioning evolved from a level of recognition up to a level of integration and coherence. For the use of the graphical organisation strategy, the evidence showed that students use was easy. The diagrammatic representation of basic cognitive skills facilitated its development, particularly those related to skills such as comparison, analogy, identifying pros and cons and sequences. To work with this strategy, students processed the source text using the previous strategies included in e-PELS, so graphic organisers were used to identify specific aspects of the text that require analysis. For example, differences and similarities between characters in a tale, analogies between known things by the students and new elements discovered in the text, causes and effects of problems stated in the source text, among others.

Quantitative data showed that 757 pupils in 27 classes from the experimental group took the pre and post tests (PLC forms A and B respectively). 85 pupils in 3 classes from the control group took the same pre and post tests. 24 out of the 27 classes in the experimental group showed an increase their reading understanding level in the posttest as compared with their level in the pretest. Two of the three classes in the control group slightly decreased their reading understanding level; the third had a small increase. A cluster analysis, for the pretest, determined that classes fell into three types, two of which had control groups. Therefore, significance and effect sizes comparison are possible within these two cluster types. 12 classes in the experimental group had significant increase in reading understanding in comparison to the control group. Effect sizes, measured with a *d* Cohen Coefficient, were up to 0.7 standard deviations, which is a medium, though relevant, size effect.

5 TOWARDS A SEMIOTIC VIEW

The definition of Interactive Graphic Organiser as a combination of non-linguist representations (shapes, symbols and arrows) with linguist elements (words and phrases) means that IGO is full of signs. Although categories are not exclusive, IGOs incorporate Peirce's classic distinction between iconic, indexical and symbolic signs (de Souza

2005). There are iconic signs, which resembles something, in the form of links pointing to IGOs functionalities. As a sign is not iconic until the interpreter recognises it as such, if the cursor is on the sign, a micro help message comes into view.

There are indexical signs, which indicate something, in the form of connectors to facilitate relations. As a sign is not an index until the interpreter recognises as such, when adding a new shape, the relationship, because it is pre drawn, appears simultaneously with the shape.

There are symbolic signs, which arbitrarily represent something, in the form of text boxes to enter conventional words or phrases, since words are examples of symbolic sign. Figure 9 describes IGO structure and its signs.

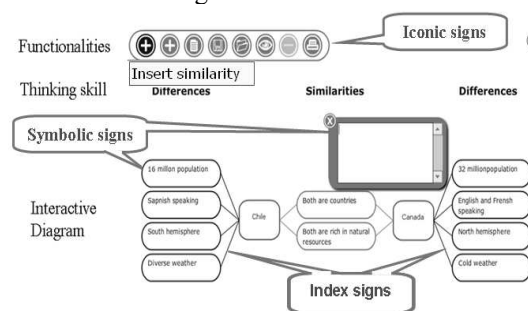


Figure 9. IGO structure and its signs.

e-PELS and other software tools built up with IGOs software components inherit the analysis as arrangements of diverse sign types.

One of IGOs major features is their high interactivity; users have to be active and participative to complete with words and phrases to obtain meaningful diagrams. The conceptual framework Semiotic Engineering (de Souza 2005), describes IGOs since it is a semiotic theory of human-computer interaction, where interactive computer systems allow messages flow from designers to users.

Educational uses of IGOs include (a) content visual presentation; (b) students' learning activities development for either class work or homework; and (c) reading comprehension and text production. In these cases, instructors and students engage in teaching/learning activities. Business uses of IGOs include (a) content visual presentation for developing companies' strategic plans and (b) linking strategies to operations. In these cases, managers and employees engage in activities for planning/executing strategies. All these cases can be explained through semiotic mediation (Hull and Saxon 2009); that is, the mediation of something by someone to someone else by means of the modality

of language. Semiotic mediation is practical to understand the engaged activities of instructors and students and that of managers and employee when they use interactive graphic organisers.

Information Systems also help to analyse IGOs and e-PELS. One angle to describe information systems is through a six fields ladder: physical world, empirics, syntax, semantics, pragmatics, and social world (Stamper, et al., 2000). This Semiotic perspective not only offers a deeper understanding about IGOs and e-PELS, but also about their milieu, ranging from technology to social issues. For example, for e-PELS, the physical field or level includes school classroom and computer laboratory hardware, settings, budget and properties. The empiric level comprises different existing technological capacity, communication channel. The syntactic level considers IGOs diagrams' formal structure, language and logic; associated software and files. Semantics consider IGOs user's meanings and significations. Pragmatics includes IGOs diagrams purpose (development of cognitive skills) and participants' interactions and negotiations. The social world comprises participants' commitments, teaching and learning or managerial styles approaches and ICT use abilities.

One of the starting points for this paper was to seek for a conceptual viewpoint that united the initial separated learning and technological backgrounds. An interesting approach that looks simultaneously at learning and use of technology is Social Semiotics (Skaar 2009), which describes the connections between learning and the use of technology. First, learning is seen as taking place through the semiotic work performed with created signs and texts. Second, digital technology establishes new premises for learning through the meaning-creating process.

Semiotics assumes that sign-systems play a major part in the construction of social reality and that reality connect closely with sign-systems in which they are experienced (Chandler 2007). From this point of view, the visual technology described here, or rather, the sign-system sought to play a role in the construction of social reality. That is, at least in Chile, on the one hand, children, through educational use of IGOs, having a better reading understanding and writing producing and, on the other hand, small and medium size company managers, through business use of IGOS, having better planning and executing of their strategies.

6 CONCLUSIONS

As stated in the Introduction, this paper attempted to provide a first approach to look at the IGOs from the semiotic viewpoint. As Semiotics is a huge field, this initial treatment cannot claim to be comprehensive. However, within the range of this short analysis, it does give a unified conceptual view and provides insight into the practices of those involved around IGOs and their applications.

This paper not only described the sign-systems, or visual technologies, but also showed that they had an impact on, or stood for something to, their users. According to Semiotics, the IGOs sign-systems for developing cognitive skills consist of pre drawn diagrams (the representamen); users interacting with the diagrams (the object) and the idea that IGOs repeated and systematic use produce cognitive automaticity (the interpretant).

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