Interactive Graphic Organizers: A case of ICT curriculum integration in higher education

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Abstract

VirtuaLab-USACH developed Interactive Graphic Organizers (IGOs), a software application built with components on Adobe Flash and Air platforms. IGOs are modular, interactive and facilitate both students thinking skills development and teachers interactive visual content display.

This article presents some results from IGOs curriculum integration evaluation. IGOs were integrated into learning activities in an Information Systems Design course (belonging to the seventh of twelve semesters in Industrial Civil Engineering degree course at the University of Santiago, Chile).

A cuasi-experimental design was used where students from the experimental group (the course) were invited to use the IGOs in their learning and assessment activities.

A working hypothesis was stated for the curriculum integration; and comprehensive tools were developed for data collection.

Introduction

An Interactive Graphic Organizer is a combination of non-linguistic representations (shapes, symbols and arrows) with linguist elements (words and phrases). Interactive Graphic Organizers facilitate the discovery and design of patterns, relationships, and interrelationships, as well as helping to develop creative thinking.

This article presents a case study in which a set of IGOs associated with a group of thinking skills were integrated into a course curriculum in higher education. The paper begins with a description of the research problem. It then presents some background information: a conceptual summary, a brief IGOs description and the ICT curricular integration model used. Next, it presents the evaluation design. The main findings are presented in terms of quantitative impacts and students perceptions. Finally, a couple of conclusions are outlined.

The problem

The research was conducted 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. The course runs for 17 weeks with 102 hours per semester. Week activities include 1 hour lecture; 2 hours seminar, 2 hours laboratory assignment. Other semester intermittent activities were 12 hours case discussion and time for assessing.

According to the course lecturers, after several semesters running and assessing students on the course, they had noticed that the students evidenced an inadequate thinking skills level important for course content understanding. Students usually confuse problem origins and consequences; incorrectly identify attributes to compare objects; have difficulties structuring sequences and so on.

For example, as the course starts, students must state a real organizational problem, in which information management is an important component. The problem wording was of great complexity in previous semesters, students showed weaknesses in their ability to distinguish between problem symptoms (causes) and problem consequences (effects); often the problem was associated with some of its symptoms.

Another example is their difficulty to complete a promise structured syntactic (actor 1 + fixed verb + action + actor 2).

Given the diagnosis, and as Interactive Graphic Organizers software was designed to practice and develop thinking skills, it was decided to integrate the IGO software into learning activities to improve students evidence production through developing thinking skills critical to the subject understanding.

The IGOs' use sought to develop on the students a deep learning approach through making available to them these technological artefacts.

Background

Because the IGO software curricular integration looked for students memorable experiences, background elements presented are deep learning, interactive graphic organizers and ICT curricular integration model.

Deep Learning

Deep learning is immersed within the constructivist view and is the opposite of memoristic or repetitive learning [1]. Deep learning arises when substantive and non-arbitrary relationships are built between what is already known (previous content) and what is to be learnt (new content) [2, 3, 4]. Thus, learning is an active process where new understandings are built by designing and creating meaningful experiences for learners. This should facilitate the organization of learner's cognitive structure [5, 6].

Three requisites are required to accomplish deep learning. Firstly, logical significance of content, contents should be intentionally organised so that learners can build relations between new content and their previous knowledge. Secondly, psychological significance of content, related to the internal representation made by learners of logical significant content. Thirdly, learners' favourable attitude to substantively, profoundly and no literally relate their cognitive structure with the new material [7, 8]. The presence of deep learning in educational environments depends upon de mediation between didactic (methods and strategies) and learning outcomes. 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.

Knowledge construction, either semantic or procedural, is particular process that requires a logical set of operations or courses of actions.

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 [9].

Interactive Graphic Organizes

The use of visual aids and diagrams facilitates thought clarification, reinforces understanding, integrates new knowledge and allows misconception identifications [10]. Visual artefacts also facilitate patterns interrelationships and interdependencies discovery, as well as developing creative thinking [11].For example, through a similarities and differences diagram, a student has a visual technique that enables him/her to compare two or more objects or events.

The software Interactive Graphic Organizers are visual diagrams developed using software components technology [12] and implemented in Adobe Flash. This allows easy integration into Web environments and Flash compatible software.

As shown in Figure 1, each organizer has functionalities in a tool bar to create, edit, remove, store, retrieve and print what a student is developing or has completed interactivity through adding and editing graphic forms.

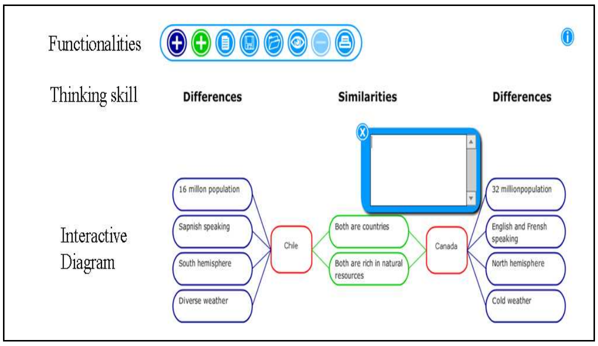

Figure 1: IGO structure

The Interactive Graphic Organizers features grant them a high degree of interactivity, allowing cognitive skills development. In particular, IGOs can be used for (1) cognitive skill development and (2) reading comprehension:

Cognitive skills development: IGOs are particularly useful for challenges where students are required to develop an idea or order thoughts. Here IGOs become well-defined structures that guide students thinking; students enter in a systematic dialogue with themselves (meta cognition and meta learning) assisted with a technological tool.

Reading comprehension: IGOs provide direct support to reading understanding by allowing the reader-learner to make sense and extract meaning before, during and after reading [13].

Interactive Graphic Organizers are grouped into six categories, one is cognitive abilities and includes the following diagrams: Analogy, Brainstorming, Cause and Effect, Comparison, Definition, Differences and Similarities, Domino Effect, Dual Descriptor, Fishbone, Hierarchic Semantic Map, Hierarchy, Orbital, Pro Con, Puzzle, Pyramid, Semantic Map, Snapshot, Spider, Synonym and Antonym, System, and Timeline.

ITC curricular integration

ICT effective use in education is widely reported and interesting examples are [14, 15, 16, 17, 18, 19, 20, 21]. The literature, however, is not as abundant on ICT curricular integration models [22]; for example, there are proposals for languages [23], science and social science [24]. All place great emphasis on the teacher willingness [25] and are based on means and content provision [26, 27].

The authors work with an ICT curricular integration model based on learning to learn; skills and values development; and teachers as facilitators of students learning [28].

This model proposes learning outcomes specification through skills and abilities (cognitive domain); values and attitudes (affective domain); significant contents (knowledge architecture) and methods or learning activities. Contents and methods are the means and skills, abilities, values and attitudes are objectives; all these are arranged in a double T [28], as shown in figure 2. The model includes contents and methods assessment.

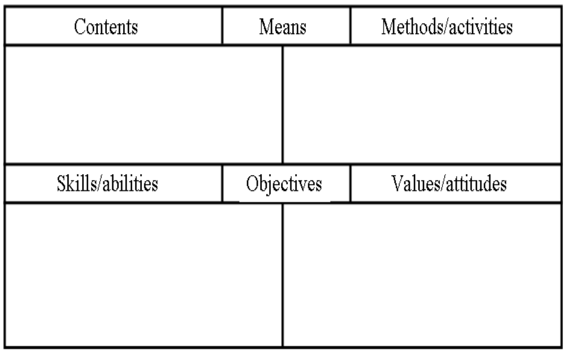

Figure 2: Double T

The T model facilitates the curricular integration of ICT as means for learning activities, which ensures that ICT are used as a strategic tools [29], particularly to facilitate evidence gathering and assessment by portfolio.

Research Design

A cuasi-experimental design was used with control and experimental group. Students on the course during 2008 first university term constituted the experimental group. Student on the same course but taken on 2007 second university term constituted the control group. Therefore, different students constituted the control and experimental groups.

The experimental group (the course) was invited to participate in learning activities that integrated the IGO software. Seven IGOs were used in 10, out of 19, students learning activities. IGOs implemented were: Cause and effect (problem, origins and consequences discrimination); Generic Grid (events analyses under variables); Definition (concept construction); Box Linker (relations between initial and other elements); Comparison (non-randomly objects comparison); Brainstorming (ideas representation); and Sequence (dependency relations).

Typically, learning activities included learning outcome identification; activity name and brief description; IGO(s) used (if appropriate), and step by step instructions for producing the digital and physical evidence. The following figure illustrates a learning activity (challenge) that integrates the software IGO "Cause and Effect".

Challenge 1: Identify and summarize a real information problem.

Description: You will need to state an information problem, differentiating it from its causes and effects.

File: CauseEffect.swf

Hint: Use software tool tips o find IGO functionalities. For any doubts, please ask your assistant.

Instructions

1. Download, open and save a Word document with the name "InformationProblem.doc". Enter your name, course and company name.
2. Briefly describe the company and its information problem.
3. From your description, list problem's relevant issues.
4. Download and open CauseEffect.swf. Enter your problem in the red box. Use the blue + button to insert cause boxes, enter causes in the blue boxes. Use the green + button to insert effect boxes, enter effects in the green boxes. Save the file with "InformationProblem.ceigo" as its name.
5. Once done, please save all files and upload them to your working folder.

Figure 3: Learning activity.

Learning activities assessment was base don previously prepared checklists. Figure 4 shows the checklist for the above learning challenge (figure 3).

Indicator	Description		Max %	%
Evidences	InformationProblem.doc (description and issues list)		10	
	InformationProblem.ceigo (causes-problem-effects)		5	
Pertinence	Correctly define.	Problem	10	
		Causes	10	
		Effects	10	
Consistency	Between .doc and .ceigo.		10	
Synthesis	Analysis and conclusion.		45	
Results			100	Σ

Figure 4: Checklist.

To evaluate the impact of the curricular integration of the IGO software on students learning and study practices quantitative data gathered from the experimental and control groups was analysed as well as analysis made from data gathered through interviews, focus groups, and student activities observation.

FINDINGS

Findings regarding the use of IGOs by the engineering students are presented both quantitatively and qualitatively.

Quantitative Analysis

The effects of two IGOs on students' learning are presented; the first one relates to the use of the Generic Matrix to develop a group activity, and the second, it is the use of the Cause-Effect Diagram on individual activities.

Generic Matrix. To compare the results on group learning, the groups' reports by the 2008 first university term (experimental group) were compared with the groups' reports by students on 2007 second term (control group). The control group was formed by a different group of students and they did not use any of the graphic organizers.

Both, experimental and control groups, were given the same task: to structure a promise network [31]. To work on the task, the students form small work groups of 3 or 4 members. The control group was formed by 9 workgroups and the experimental group by 14 workgroups.

The different between the control and experimental group is that to structure the promise network, the experimental group was asked to additionally use and complete a Generic Matrix indicating actors, verbs and actions (elements of the promise network). The control group, on the other hand, directly structured the promise network.

The next figure presents the structure of the generic matrix:

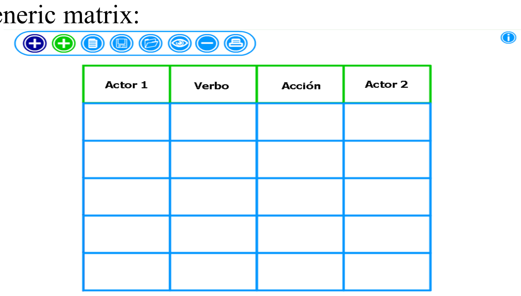

Figure 5: Generic Matrix IGO

The quality of the promise networks by the control and experimental groups were assessed by a two experts using a 1 to 7 scale (assessing scale used in Chile).

Groups	mean	stdv
Control	5.633	.9500
Experimental	6.571	.3667

Table 1: Mean and Stdv of promise network task.

The results from the assessment were normally distributed and a t-test was used to compare the means. The experimental group shows a significant improvement compared with the control (t-student = 2.83, p-value = .01, df = 9 and $\alpha = .05$)

Thus, the use of the generic matrix IGO had a positive impact on the task related to structuring a promise network.

Cause and Effect Diagram: The same groups—control and experimental—were assessed regarding now their individual skills to formulate and frame a problem situation. The experimental group, formed by 45 students, used the IGO called "Cause and Effect Diagram" to facilitate the task. The control group, formed by 35 students, did not use any IGO.

The following figure shows the structure of the cause and effect Interactive Graphics organizer.

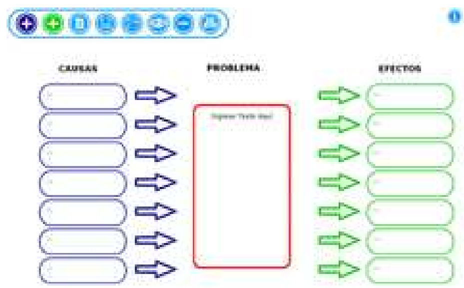

Figure 6: Cause and Effect IGO.

The quality of the problem formulation and frame was assessed by two experts.

Groups	mean	stdv
Control	5.523	1.292
Experimental	6.066	0.949

Table 2: Mean and Stdv of problem formulation task.

The data from the assessment were not normally distributed so a non-parametric analysis was used. The analysis indicates that the experimental group shows a significant improvement compared with the control (U de Mann-Whitney = 599.5, p-value = .03, and $\alpha = .05$).

Thus, the use of the cause and effect IGO had a positive impact on the task related to formulating and framing a problem situation at individual level.

In both cases, the use of IGOs by students on their group tasks and on their individual tasks shows significant improvements compared to those students that did not use this technological artifact.

Students perceptions

Information from students showed that IGOs curricular integration most valued aspects were: (1) structural thinking, (2) keep focus on what matters, (3) advantages of using IGOs, and (4) usability strengths of using IGO. Students also had some critical observations, such as course structure and some aspects of usability.

Structural thinking. Students thought that IGOs use helped them not only to think but also to think more structurally, think with more sense, organise ideas more easily and synthesise more rapidly. Some students' remarks were:

"I found that the tool was useful to organize ideas and to enable the identification of what are causes and what are effects… One is conditioned to think in that way when faced with a problem and have the experience to deal with. I will know that the obtained optimal response is modelled following the pattern of the graphic organizer, which allows avoiding confusion, leaving a record of thoughts and one becomes aware that everything can be so orderly."

"One realizes that in reality this is spinning, and as I said to my fellow students, it helps us organize and focus the ideas, because sometimes you have an idea in your head, but a thousand things come to mind, while here synthesis is easier and so useful"

"It is super useful as we work here, because is so easy to deviate and you say ah I want this but the company wants that, but I'm solving a problem and have to be more specific. This is something incredible, one is forced to synthesize."

Focus on the relevant. Students considered that using the IGO software allowed then keeping focus on what mattered to the course: solve an information problem through an information system design and prototype. A couple of quotes from students are:

“"IGOs serve to emphasize the central fact, and do not misunderstand the sense of making new things, very useful for the course purposes. The clear problem definition made me aware that I had to design a solution."

"What is sought is to solve an information problem and avoid being impressed by complex programming and in that IGOs were absolutely useful."

Course strengthening. Students said that IGOs use strengthened the course, because the use of innovative tools. Students, for example, said:

"I learnt to use a tool which helps me to solve problems. There is a perception change from programming to design. It is useful and with a lot of potential for future use".

"I appreciated the weekly deliveries; it keeps a good study pace and the use of IGO tools helped not only to understand and learn course content, but also to finish the assignments on time"

IGOs advantages. IGOs use presented various advantages for students, among them:

"They accomplish its function for visually present and understand course content. Information within the IGO allowed an easy ride on course contents through easy organization of ideas, concepts and information".

"IGOs allowed permanent contact with the initial problem. May be, without the Interactive Graphic Organizers, the solution would have not been possible and we had ended with a set of pretty windows only. The second time I used the Cause and Effect IGO, I realised how the course unit are related and it was so much easier to learn".

IGOs usability. Students recognised that IGOs are easy to use; at first sight, colours are attractive; and they are visually simple. Students reckoned that IGOs simplicity is their most outstanding feature, in contrast to traditional educational software, which have infinity options and buttons, many never used.

Disadvantages. Students mentioned two aspects that can be categorised as disadvantages. First, they found difficult to get used to the course style with weekly assignments and practically giving a couple of hours daily. "At the beginning it is difficult, it is hard to assume continuous work, until you get used to it", as one student put it.

Other critical points were the small amount of text that IGOs allowed and the complexity to save them. Both amendments were quickly introduced to IGOs.

Conclusions

Considering a) that, the opportunity sought by this study was the IGO software curricular integration to develop and improve student thinking skills, critical for content understanding and b) quantitative and qualitative results, it is possible to conclude that:

- Students enhanced their course understanding though the improvement of some their thinking skills, which were developed and exercised with IGOs.
- Interactive Graphic Organizers can successfully be used as a methodological resource for learning activities.

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