Criss-crossing Cognitive Flexibility Theory based research in Portugal: an overview

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Abstract

This article addresses research conducted in Portugal on the application of Rand Spiro's Cognitive Flexibility Theory, describing work developed in the last decade. The studies presented range from the theory itself and the pedagogical and technological principles it defends as applied to learning, to how teachers interpret and translate it in the development of teaching materials, or even on how it can be used for setting up communities of learning an practice. Still other studies address how CFT can be used as a cognitive tool for deconstructing knowledge and lead students to reflect upon this process in distributed learning environments.

Keywords

Cognitive Flexibility Theory, deconstruction, thematic criss-crossing, hypertext, distributed learning environments, learning, transfer of knowledge

Cognitive Flexibility Theory (CFT), as proposed by Rand Spiro in the 80's, has given rise to several studies both in the United States and in other parts of the world. In Portugal, this theory found adepts in universities and schools, and research studies, mainly for purposes of post-graduation degrees – PhD and MA dissertations – started being published in the late 90's.

Given the disperse and diverse nature of the body of knowledge developed so far in these last ten years, the present paper attempts to bring together, analyse and summarise all the contributions research studies have added to the area of CFT in Portugal, therefore accounting for the impact it produced amongst an evergrowing community of academics and researchers (Moreira, 1996; Carvalho, 1998; Carvalho & Dias, 2000; Carvalho, 2001; Fonseca, 2000; Magalhães, 2002; Marques, 2003; Carvalho & Pereira, 2003; Sousa, 2004; Marques & Carvalho, 2004; Marques & Carvalho, 2005; Moreira et al, 2005; Lei, ongoing, Pedro, ongoing).

The research conducted in Portugal can be organised in three main streams. One stream deals with studies centered on CFT itself, through evaluation of cognitive flexibility hypermedia prototypes and also their impact on learning (Moreira, 1996; Carvalho, 1998; Carvalho & Dias, 2000; Fonseca, 2000; Magalhães, 2002; Sousa, 2004; Marques & Carvalho, 2004 and Lei, ongoing). Another deals with studies that attempt to clarify how teachers interpret and apply the theory towards the development of CFT materials (Pedro, ongoing), the development of electronic portfolios (Moreira et al, 2002) and the setting up of communities of practice (Moreira et al, 2005), among others. Finally, another research stream whose focus is set on knowledge deconstruction according to CFT and on challenging students to reflect on their knowledge through the participation in discussions supported by distributed learning environments (Carvalho, 2001; Carvalho & Pereira, 2003; Carvalho et al., 2004; Marques & Carvalho, 2005).

Apart from a brief account of CFT itself, contributions will be described, examples given, and an overview of research conducted so far put forward as an historical account of CFT studies in Portugal. We also aim at pinpointing the issues that still need to be tackled and/or developed in future studies in this domain.

Cognitive Flexibility Theory

According to Spiro & Jehng (1990:165) "[…] cognitive flexibility (is) the ability to spontaneously restructure one's knowledge, in many ways, in adaptive response to radically changing situational demands...This is a function of both the way knowledge is represented (e.g., along multiple rather than single conceptual dimensions) and the processes that operate on those mental representations (e.g., processes of schema assembly rather than intact schema retrieval)."

The foundations of this theory lie basically on transfer of knowledge acquired at initial stages of learning to more advanced ones and that is why it purports that, for this to happen, information should be presented from multiple intellectual perspectives that stem from case studies that act as diverse instantiations of knowledge in context. In fact, CFT defends that for learning to happen teaching will have to be context-dependent, therefore fostering the emergence of knowledge construction, relying on the power of hypertext/hypermedia (cognitive flexibility hypertexts) to facilitate navigating through complex knowledge domains.

The theory's basic principles are that multiple representations of knowledge should be embedded in learning tasks, teaching materials should be based on context-dependent knowledge and avoid simplification, teaching should be case-based (knowledge deconstruction for reconstruction), and links between components of knowledge explicitly stated and explained.

CFT is a constructivist theory of learning and instruction that attempts to remedy the problems associated with *advanced knowledge acquisition*, i.e. learning beyond the initial stage of a subject area. Therefore the aims of advanced knowledge acquisition should be different from those of introductory learning. At the introductory phase, the goal is to expose the learner to the content in order for him/her to recognize and/or recall it. At the advanced knowledge acquisition phase "the learner must attain a deeper understanding of content material, reason with it, and apply it flexibly in diverse contexts" (Spiro et al., 1988: 375). It is at the advanced stages of knowledge acquisition that students have more difficulties in acquiring and transferring knowledge due to its complexity and irregularity.

CFT suggests some techniques in teaching that aim to facilitate the mastery of knowledge at more complex levels of learning, avoiding problems related to oversimplified approaches to application/transfer which in turn allow for more cognitive flexibility.

This theory approaches the subject matter in two complementary ways (Spiro et al, 1987). First, the case is divided into small units, the mini-cases. Identified the themes (concepts or points of view) to analyse or deconstruct the mini-cases, it is necessary to write a thematic commentary explaining how a general theme applies to the mini-case – this is the deconstruction process. The other process, inspired in Wittgenstein "Philosophical Investigations", is the thematic criss-crossing. Given a theme or a combination of themes the learner is conducted through mini-cases of different cases, to which the themes apply.

Since this theory emphasizes repeated presentations of the same material but in rearranged instructional sequences and from different perspectives, it is best delivered via a similarly featured medium: hypertext. Hypertexts provide non-linear links that allow for multiple dimensions of knowledge representation, for multiple interconnections across knowledge components and so on (Spiro et al., 1992). These features allow learners to interact in contextualised activities that are cognitively manageable in order to overcome the tendency of oversimplifying learning problems and activities (Jacobson & Spiro, 1994; Jacobson et al., 1996; Jacobson, 1997).

Studies

Following this necessarily brief presentation of CFT, we will describe the studies conducted about the theory and its implications for learning and teaching, knowledge construction and setting up of communities of learning and of practice, and the implications of its adoption in distributed learning environments. These studies will be presented by author(s) and date, spanning chronologically from 1996 to 2005.

Moreira (1996)

Moreira's study has explored the possibility of developing the cognitive flexibility of future teachers of English as a Foreign Language with a focus on the management of

errors that occur in classroom situations. From the use of different educational formats based on computer-assisted learning and aiming at advanced learning stages in complex and ill-structured domains, a data-base called "Mistake Management – Cognitive Flexibility Development for Teachers of English as a Foreign Language" was developed in HyperCard, according to the theoretical and design assumptions of CFT.

The two groups involved in the study were enrolled in English Teaching Methodology in the 2nd semester, 4th year of Portuguese-English and English-German Teaching "Licenciaturas" at the University of Aveiro, in the academic year of 1991-92. From the total number of students in these two courses two groups were randomly selected (an experimental group and a comparison group).

The two groups participated in an experiment in which, after having been exposed to the course contents at an introductory level in class time, were required to attend eight one our individual study sessions using the computer in two distinct formats, according to the research treatment they had been assigned.

The comparison group was given the materials in the data-base "Mistake Management" which depicted a traditional, linear structure of content presentation; the experimental group was given exactly the same materials, but structured in a flexible, "criss-crossing" mode of presentation of the contents.

The treatment for the experimental group consisted of an inter-card navigation procedure, which was based on multiple-presentation of cases where the thematic criss-crossing was made salient in terms of inter-case relevance – or lack of it. The comparison group completed an identical number of sessions, also using the hypertext, but whose structure resembled that of a book in which, by analogy, chapters and information is presented in a regular and sequential fashion.

Besides some data-gathering tasks and instruments that are normal in studies which rely both on quantitative and qualitative data, a questionnaire was used which aimed at determining a possible influence of the subjects' epistemological beliefs as to the nature of knowledge and learning, and thus clarifying the true orientation of the scores obtained by the subjects in the tests.

The results of the study revealed that the comparison group did not achieve significantly higher mean scores in the factual knowledge measures ($p=.906$). On the other hand the experimental group achieved significantly higher mean scores in all high level knowledge transfer measure tasks (near-transfer: problem-solving and far-transfer: essay, with $p=.016$ and $p=.00001$, respectively). Interaction effects were not detected between epistemological learning preferences and results obtained in different tests.

The results of this study also suggest that hypertext systems based on an approach that uses cases which are structured in such a way that they offer multiple representations of knowledge which in turn emphasise critical interconnections between different structural and surface knowledge components can be superior in their effectiveness for the preparation of students in their use of knowledge in new way and in novel situations.

The study led the author, together with is research team, to develop two other prototypes – BARTHES and DIDAKTOS – which were subsequently the object of several studies, as can be seen along this article.

Lei (ongoing) expanded the scope of this study by enlarging the knowledge base of her cognitive flexibility hypertext, developed in DIDAKTOS, beyond the scope of the present perfect, adding to it modal and phrasal verbs, etc.

Carvalho (1998)

The study conducted by Carvalho (1998) evaluates Cognitive Flexibility Theory and analyses the importance of "Thematic Commentaries" and "Thematic Criss-Crossing" in knowledge transfer (near and far transfer) to new situations. The knowledge domain is literature, namely Eça de Queirós's novel "Cousin Basilio".

Nine themes were identified to approach the novel. The chapters of the book were divided into five Cases, each one ranging from four to nine mini-cases (table 1). Each mini-case is deconstructed through the applied themes and its thematic commentaries. More information about the novel and that era is available in the Context, respectively Context of the novel and Context of that era. Five thematic criss-crossings were defined.

Chapters of the novel	Cases	Mini-cases	Context of the novel	Context of that era	Thematic commentaries
I-III	I	8	8	3	37
IV-V	II	7	7	4	37
VI-VII	III	6	6	4	35
VII-XIII	IV	9	9	5	36
XIV-XVI	V	4	4	2	15
Total	5	34	34	14	160

Table 1- Components of the process of deconstruction of "*Cousin Basilio*: multiple thematic criss-crossings"

Three hypermedia versions of "*Cousin Basilio*: multiple thematic criss-crossings" were developed (table 2). One of the versions applies Cognitive Flexibility Theory (CFT) principles, the two others don't allow access either to 'Thematic Criss-Crossing' (NCC: No Criss-Crossing available) or to 'Thematic Commentaries' (NTC: No Thematic Commentaries available).

Hyperdocument 1 CFT Cognitive Flexibility Theory	Hyperdocument 2 NCC No Criss-Crossing	Hyperdocument 3 NTC No Thematic Commentaries
Themes description	Themes description	Themes description
Deconstruction: Mini-cases, indexed themes and thematic commentaries	Deconstruction: Mini-cases, indexed themes and thematic commentaries	Deconstruction: Mini-cases and indexed themes
Thematic criss-crossing (pre-defined, with thematic commentaries)	Designation of Thematic criss-crossing only	Thematic criss-crossing (pre-defined, without thematic commentaries)
Free Thematic criss-crossing	(not available)	Free Thematic criss-crossing
Table of contents	Table of contents	Table of contents

Table 2 –Structure of the three hyperdocuments "*Cousin Basilio*: multiple thematic criss-crossings"

The research design was quasi-experimental, and it involved three groups of undergraduate students (N=42), who were enrolled in Portuguese Literature studies at the University of Minho, in the academic year of 1996-97. Each group worked on one of the three hypermedia versions and is referred to by its acronym. Data was collected from several instruments: a test for evaluating knowledge transfer, a "Learning Preferences" scale (containing the following dimensions: 'complex knowledge acquisition', 'autonomy in learning', and 'preference for complex knowledge'), a questionnaire of opinion about the hyperdocument, and another questionnaire about the subjects' computer literacy.

According to data analysis, statistically significant differences were obtained among the three groups (p=.0009) in the pre-test; therefore the analysis of gains was conducted from pre-test to post-test (table 3). No statistically significant differences were found between the three groups (p=.1009), but CFT had the best results and NTC the worst.

Groups	CFT Mean rank	NCC Mean rank	NTC Mean rank	H	Statistical significance
Total	25.69	21.71	15.67	4.59	p=.1009
Reproduction	18.87	27.04	18.54	4.36	p=.1129
Near transfer	24.94	22.25	16.04	3.69	p=.1579
Far transfer	25.19	20.82	17.38	2.883	p=.2366

Table 3- Statistical analysis of gains from pre- to post-test (Kruskal-Wallis)

We realized that "Thematic Commentaries" were responsible for statistically significant differences (p=.0071) between groups CFT and NTC (table 4). In pre-test results no statistically significant differences were obtained (p=.6091).

Post-test	CFT Mean rank	NTC Mean rank	Z	Statistical significance
Total	18.12	9.67	-2.69	p=.0071
Reproduction	14.50	14.50	0	P=1
Near transfer	17.66	10.29	-2.347	p=.0189
Far transfer	17.12	11.00	-2.02	p=.043

Table 4 – Statistical analysis of post-test results of groups CFT e NTC (Mann-Whitney U)

"Thematic criss-crossing" didn't show statistically significant differences between groups CFT and NCC, although CFT had better results on near and far transfer (table 5).

We think that this result may be explained by the positive attitude of all subjects of the NCC group towards 'autonomy in learning'.

Transfer	CFT Mean rank	NCC Mean rank	Z	Statistical significance
Total	16.97	13.82	-.89	p=.3711
Reproduction	12.78	18.61	-1.83	p=.0666
Near transfer	16.41	14.46	-.60	p=.5459
Far transfer	16.97	13.82	-.98	p=.3258

Table 5 - Statistical analysis of gains of groups CFT and NCC (test Mann-Whitney U)

All three groups obtained statistically significant differences from pre-test to post-test, according to Wilcoxon signed-rank (CFT p=.004, NCC p=.001, and NTC p=.0022). The subjects' opinion about the hyperdocument was very favourable, not only about its structure, orientation and usability but also its contents.

When NTC and NCC groups compared their hyperdocuments with CFT's, they concluded that although the CFT hyperdocument was more complete, it was less challenging. According to test results and the NTC and NCC groups' opinion, we would suggest that hyperdocuments structured according to Cognitive Flexibility Theory principles should be more challenging in order to involve the user in a more active process of knowledge construction. This idea conducted to further studies - Carvalho & Dias (2000), Carvalho (2001), Carvalho & Pereira (2003), and Marques & Carvalho (2005).

Carvalho & Dias (2000)

A Web version of the hyperdocument "*Cousin Basilio*: multiple thematic criss-crossings" was made available (fig. 1). The content is the same as the document described in Carvalho (1998), but the interface is different[1]. The study conducted focuses on challenging students to try to conceive the thematic commentaries during the deconstruction process, and to define the thematic criss-crossings before reading each one. Students were first invited to explore a case (in the deconstruction process) and a thematic criss-crossing. Only then should they try to conceive the thematic commentaries, during the deconstruction process, and define the path of the thematic criss-crossings.

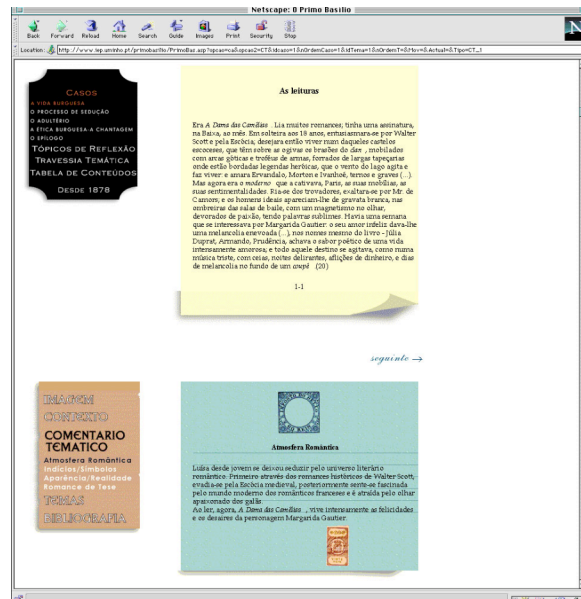[1] URL of Cousin Basilio http://www.iep.uminho.pt/primobasilio

Figure 1 – Mini-case and thematic commentary of "Cousin Basilio: multiple thematic criss-crossings"

The sample integrated 19 subjects, undergraduate students enrolled in Portuguese Teaching at the University of Minho, in the academic year of 1997-98. All of them except one were females.

The quasi-experimental study with a single group, occurred from April to May 1998. It was structured in three parts: the first one focused on reading the novel and do the pre-test, the second centred on the exploration of the Web site, and finally, during the third part, students answered the post-test and had to write a report about the site, its content and interface.

According to the Wilcoxon signed rank test results from pre to post-test showed statistically significant differences (p=.0002) as in the previous study. Ten out of the nineteen subjects accepted the challenge proposed, but only four kept faithfully to the challenge. These mentioned "*I accepted the challenge, because it helps to learn deeply*" and "*when I tried to put the thematic commentaries into plain words, reading them in the Web site afterwards, I verified that some of my ideas were wrong, but others were just completed*".

Subjects referred to their interest in the content of the site and they agreed with the themes selected to approach the novel. They also mentioned that they felt the thematic criss-crossings a little bit repetitive and therefore they did not fully explore them - "it was boring".

Based on this study and on the previous one (Carvalho, 1998), a new challenge, focusing on the learner engagement in learning, was designed (Carvalho, 2001) and tested (Carvalho & Pereira, 2003).

Carvalho (2001), Carvalho & Pereira (2003)

Based on the learning results obtained in previous research and on the subjects' opinion (Carvalho, 1998; Carvalho & Dias, 2000), Carvalho (2001) decided to keep the

deconstruction process with its multiple perspectives of analysis and to demand from the students a more active role in learning, instead of reading the information available only in the thematic criss-crossings. In this study students were invited to reflect about the knowledge deconstructed and give their solution to a problem or question stated in a Web forum. Moreover, they also had a chat session every week at 6 pm, to discuss a few things about the case under exploration or to clarify doubts with the teacher.
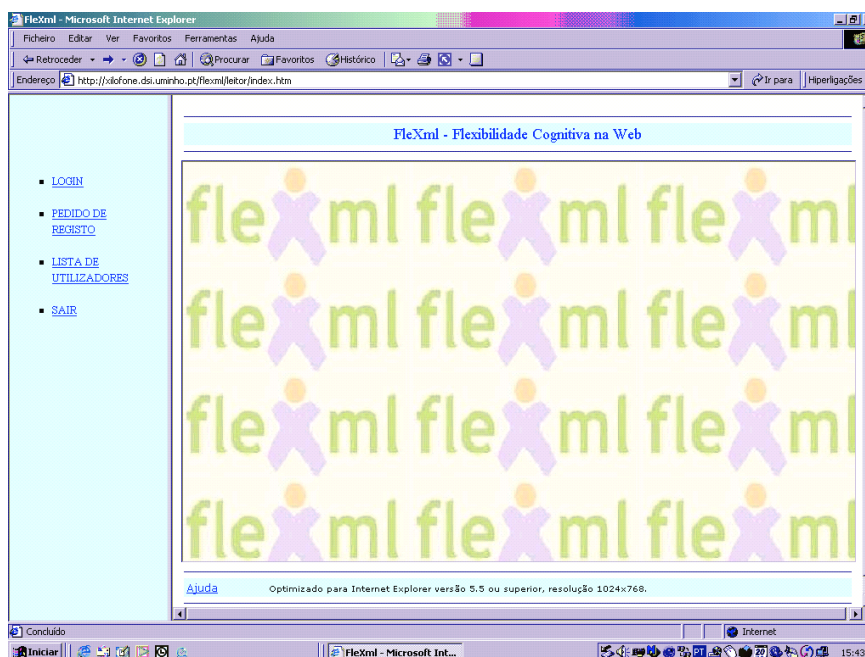

Figure 2 – Homepage of the Web platform *FleXml*

A Web platform, *FleXml*[2] (fig. 2), was developed to support the new approach (Carvalho et al., 2002). It includes to each course: themes description, cases to be deconstructed, search of themes and cases, table of contents, forum, chat, students' notes, students track online, and teacher's announcements.

A course on Latin Language and Culture, called "Sapere Aude"[3], was developed and implemented on the platform (fig. 2). "Sapere Aude" includes fourteen Themes, relevant to the study of Latin Language and Culture, and six Cases that integrate nine texts (mini-cases) from different Latin authors (Table 6).

Cases	Mini-cases	Thematic commentaries	Complementary information				
			Author	Context	Similar texts	Complementary readings	Bibliography
1. Rome, *caput mundi*	9	26	9	8	6	6	9
2. Rome, love and life	9	32	9	7	7	3	9
3. In Rome with Marcial	9	41	1	1	8	5	1
4. Romans and gastronomy	9	34	9	8	6	4	9
5. *Panem et circenses*	9	36	9	7	5	5	9
6. Writers and books	9	31	9	8	7	7	9

Table 6 – Structure of the deconstruction process of the subject matter "Sapere Aude"

Each mini-case (constituted by a short text in Latin from a Roman writer) has a translation available, and students have to read all thematic commentaries (fig. 3). Moreover, students also have access to information about the author, the context (Roman costums). Other texts of the same author (similar texts) or texts from different authors about the same subject (complementary readings) are also available. Finally, the references (Bibliography) used to write the thematic commentaries.
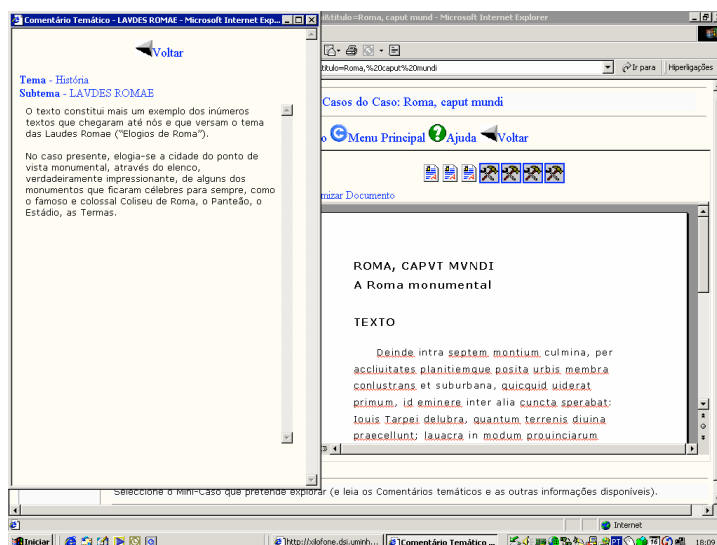

Figure 3 – Mini-case of the case "Rome, Caput Mundi" and a Thematic Commentary about History

A quasi-experimental study with a single group (Schumacher & McMillan, 2000) was conducted. Seventeen undergraduate students, enrolled in Latin at the University of Minho, integrated the sample.

This study was carried out from February to May 2003. It included three phases: preparatory, exploratory, and concluding phase. During the *preparatory* phase, students were invited to participate in the study, they filled in the Questionnaire on User's Identification, and the introductory session to "Sapere Aude" and the pre-test were

scheduled. After finishing the pre-test, the introductory session to "Sapere Aude" was conducted. The *exploratory* phase concerned the study of the course. Each week students were asked to read the Themes and analyse one Case, participate in the chat on Thursday at 6 pm, check the announcements and give their answer to the problem presented in the Forum. The concluding phase integrated the post-test and the Opinion Questionnaire.

The knowledge tests conducted before and after the study show a statistically significant difference (p=.0003) between these results which indicate that the course and its structure were effective in promoting learning (table 7).

Mean ranking	Z corrected for ties	Statistical significance
9	-3.622	p=.0003

Table 7 – Analysis of differences between pre- and post-test (Wilcoxon signed-rank test)

Most students (70.6%) considered that the *structure of the document* (themes, cases, and mini-cases analysed according to several thematic commentaries) helped them in learning Latin Language and Culture, but 29.4% disagreed with the number of mini-cases (nine) per case. These students would prefer less mini-cases per case.

In the *Forum* every week a new challenge or problem was available, which was related in part with the case under deconstruction. The teacher gave feedback on each answer given by the students. Most of the students (83.4%) agreed that the problem helped them reflect on the content of the document. We think that the Forum is an important feature in this Web platform. We replaced the thematic criss-crossing process of cognitive flexibility theory with the Forum. Remember that the thematic criss-crossing process is more like "follow the arrow", this means, the user only has to read the information available. With our weekly challenge in the Forum, we intended to engage students in thinking about the content deconstructed and reason to give an answer. Though they were novices in using a Forum, they didn't have any difficulty in using it.

Inquired if they would like to have other courses on the *FleXml* platform, most of the students (76.5%) expressed their agreement, because they felt that they could learn better the content under study, learn at their own pace and have access to their course from any place where there was a computer connected to the internet. However, four students showed no interest in taking other courses because they said it implies spending some hours on a computer, and they did not like it.

This study led us to conclude that the structure and functionalities of the Web platform FleXml help students to learn and to become engaged in learning. The replacement of the thematic criss-crossing process proposed by CFT with the thematic challenge in the forum seems to lead to a more engaging activity. Besides, students did not complain about seeing the same mini-cases in different contexts as they did in other studies reported by Carvalho (1998) and Carvalho & Dias (2000).

Fonseca (2000)

Fonseca's study reports on research that focused on improving English grammar teaching and learning of the present perfect at the university level. For this purpose *BARTHES* (Moreira et al, 2000), a prototype shell based on the theoretical orientations of Cognitive Flexibility Theory, was used.

The Present Perfect was chosen as the knowledge domain because of the difficulties students encounter when trying to differentiate between the present perfect and the past simple. A problem that partially lies in the fact that the Portuguese verbal form, *pretérito perfeito simples*, can be translated into English as either the simple past or the present perfect tenses. The problem persists throughout the students' English language learning experience, a fact that is puzzling because first year university students are supposed to have a good grasp of the English grammar, and hence the present perfect, given that it is taught and reviewed in pre university school years.

To attempt to offer possible solutions for the reoccurring Present Perfect problem, an experiment was designed involving two groups (experimental and control) to test knowledge acquisition mediated through an educational hypertext contrasting a linear structure – deconstruction- with a non-linear structure - thematic criss-crossing - of content presentation and to assess the effectiveness of the latter in helping students transfer knowledge and skills to novel situations.

Thirty-six subjects took part in the experiment. These were enrolled in an English I class, at the Portuguese Catholic University, Viseu, in 1999/2000. They were all Portuguese studying to become teachers of English as a Foreign Language.

Following random assignment of subjects to groups (18 + 18), six individual one-hour sessions of contact with *BARTHES* took place. Although the information contained in the hypertext was the same, the manner in which it was organised was different. The experimental group worked with the thematic criss-crossing and the control group with the deconstruction.

All subjects were given a review of the present perfect, the knowledge domain focused on in this study, in class. The next step was to give subjects a *Verbal Reasoning Test* (Almeida, 1985) and a *Quick Check Test* (Fowler & Coe, 1978) – to find out, respectively if both groups were identical in relation to their global academic abilities and their general knowledge of the English language. In order to compare the mean scores of both groups on each test, an independent samples *t* test was used. Subjects were also given an *Epistemological Learning Preferences* questionnaire (Spiro et.al, 1984) to assess their opinions about knowledge and learning.

After this initial stage, the sample used in the experiment took three pre-tests - two declarative (divided in two parts), one procedural –on the present perfect to assess their prior knowledge of this grammatical item. Results from each group on each test were subjected to an independent samples *t* test. To validate the scores of the test that assessed the subjects procedural knowledge, an inter-rater reliability test was performed.

At the end of the sessions subjects filled in the *Epistemological Learning Preferences* questionnaire again and took three post-tests. Eight students from the experimental group were interviewed about their learning performance, ease of use of the hypertext, motivation and personal opinion and ideas on the content structure. Information collected from these interviews were transcribed and analysed according to five pre-defined categories: Perception of learning, Attitudes towards instructional approach

used in this study, Amount of time and number of sessions devoted to the study with the hypertext, Ease of use of the hypertext, and Motivation during the sessions.

These five categories aimed to provide some insight as to the opinions and ideas the subjects from the experimental group had concerning this innovative approach to learning the present perfect, information that was not possible to detect from quantitative data.

Results of this study revealed that the experimental group achieve slightly higher results than the control group on the procedural knowledge test [control group: M = 35.72, SD = 19.19; experimental group: M = 36.39, SD = 20.34; t (34) = -.101, p = .920]. Significant differences, however, were found between before and after treatment results for the experimental group's mean scores on the procedural knowledge test [before treatment: M = 36.39 SD = 20.34; after treatment: M = 43.89, SD = 24.67, t (17) = -2.879, p =.01], a result that was not confirmed with the control group's mean scores [before treatment: M = 35.72, SD = 19.19; after treatment: M = 37.39, SD = 18.24; t (17) = -1.695, p = .108]. This result allowed to conclude that the subjects from the experimental group benefited from working with the thematic criss-crossing because their knowledge transfer of the present perfect was greater after the treatment than before, an outcome that was not confirmed with the control group. This might be due to learners being confronted with different contexts in which the present perfect occurred, with different explanations for each occurrence and multiple combinations of themes for different perspectives of the present perfect (i.e., semantic feature, pragmatic feature and future reference).

No significant difference was detected between the subjects' epistemological learning preferences and their post-test mean scores regardless of condition (p = .64]. Based on these results, one cannot confirm that the subjects' epistemological learning preferences constrained or enhanced their learning of the present perfect, a conclusion also drawn in two other Portuguese studies of this nature (Moreira, 1996; Carvalho, 1998). Nevertheless, mean scores obtained on the after experiment *Epistemological Learning Preferences* questionnaire was higher (42.56) than the mean score of its before (39.1) experiment counterpart. This might indicate that subjects, after working with the hypertext program, developed stronger epistemological beliefs, shifting, in some cases, their epistemological positioning.

The data obtained from the eight subjects who were interviewed indicate that these had an overall positive opinion about the instructional path they took. All of them responded favourably to three categories - perceived learning, instructional approach and ease of use. Almost all of them (7) were highly motivated and the only category that received mixed opinions was the Time category. Some subjects felt that more time should have been devoted to each session to truly understand the content presented.

Magalhães (2002)

The study conducted by Magalhães aimed at finding out the most appropriate strategy - collaborative or individual learning - for the teaching of a Short Story through a Cognitive Flexibility Hypertext in an EFL classroom.

The selected content was the Short Story *Dingo*, by F. Bennett, which was part of the extensive reading material chosen in the school where the researcher was teaching.

The application that was used for its implementation was DIDAKTOS (Moreira et al., 2001), which was also developed according to the theoretical and design assumptions of Cognitive Flexibility Theory.

The subjects were 20 of the researcher's students enrolled in 2 classes of the 11th form at school ES/3 Dr. Joaquim Gomes Ferreira Alves, in the academic year of 2001-2002.

After having been exposed to the Short Story at an introductory level, during class time, the subjects started a deeper study of the Short Story with the support of the Cognitive Flexibility Hypertext *Dingo*, this time with the use of two different class strategies: the experimental group worked with the hypertext under collaborative principles, through activities organized according to the basic principles of Cooperative Learning – interaction between students in each group under the principles proposed by Nunan (1989) for task based learning –, whereas the subjects in the control group worked individually with the same hypertext. The study included nine one-hour sessions, seven of which involved direct contact with the Cognitive Flexibility Hypertext - Dingo.

The quantitative effects of the treatment were analysed through a pre- and a post-test. These two instruments were used to compare the mean scores of the two groups after treatment as well as the learning gains obtained both by the groups as a whole and by the low pre-test scorers of each group.

Two other data gathering instruments – a diary and a questionnaire – were used to assess qualitative aspects, namely the subjects' attitude both towards the Cognitive Flexibility Hypertext and the class strategy to which each condition was assigned.

The results of this study revealed statistically significant differences between the two groups (p=.001) in the post-test. The experimental group achieved mean scores that were higher than the ones obtained by the control group from pre- to post-test (p=.0004). The pre-test low scorers of the experimental group also achieved residual gain scores in the post-test that were significantly higher than the ones obtained by their counterpart in the control group (p=.024).

Motivation of the experimental group towards the lessons was also found to be higher and steadier than the one shown by the control group. The attitude of the experimental group towards the Cognitive Flexibility Hypertext was also more favourable than the one evidenced by the control group.

The results of this study suggest that the teaching and learning of a complex and ill-structured knowledge domain, as it is the case of literature, through a Cognitive Flexibility Hypertext, will be more effective and motivating if the class activities, through which the interaction with the hypertext is established, involve collaborative learning.

Sousa (2004)

The study conducted by Sousa (2004) applied the principles of cognitive flexibility theory to primary school education - 4th grade (fig.4). The chosen subject was the environment and the hyperdocument developed called "Defenders of the Environment" (Os Defensores do Ambiente).
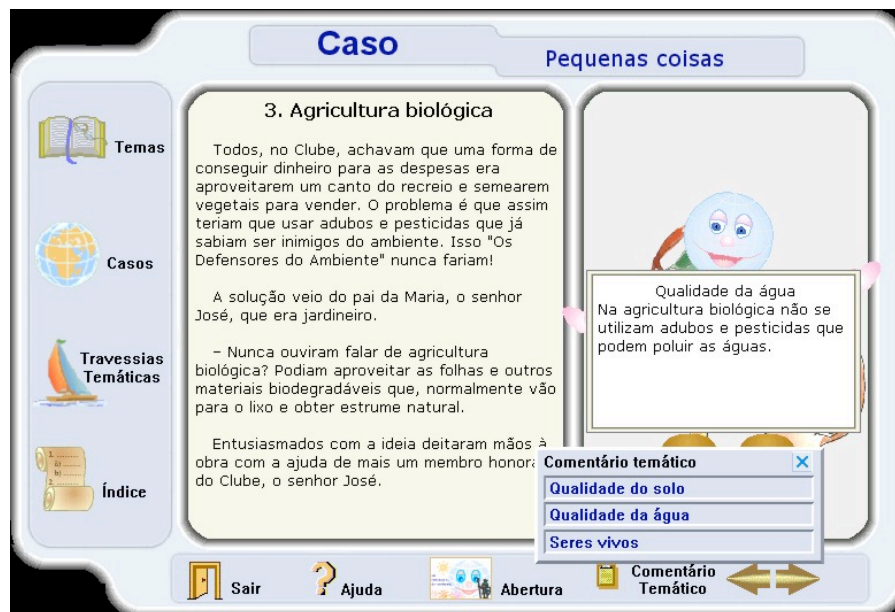
Figure 4 – "Defenders of the Environment" - Mini-case of the Case Little smart things

Seven themes were selected to approach the seven cases and stories created about the environment (table 8). Four thematic criss-crossings were defined.

Cases	Mini-cases	Thematic commentaries
1. Farm holidays	4	11
2. Back home	4	13
3. In the farm	3	7
4. Grand-parents' visit	4	12
5. A club is born	5	16
6. Earth defence	4	12
7. Little smart things	4	13

Table 8 – Number of cases, mini-cases and thematic commentaries of the hyperdocument "Defenders of the Environment"

All mini-cases had pictures related to them, and some animations appeared in the themes' description to help students understand the concepts. As the target audience of this hyperdocument were children, nine games were included to stimulate their interest in the content and amuse them. These games integrate activities such as multiple choice, fill in the blanks, alphabetic soup, association of objects.

The study is a quasi-experimental one with a single group. Twelve 4th grade subjects were included in the sample. After doing the pre-test, they explored the hyperdocument in pairs, along 8 sessions of 45 minutes. Then, they did the post-test and answered an opinion questionnaire about the hyperdocument.

According to data analysis, statistically significant differences were obtained from pre to post-test (p= .0022), as in all types of transfer except reproduction (table 9).

Transfer	Z corrected for ties	Statistical significance
Reproduction	-1,687	P= ,0915
Near transfer	-2.934	P= ,0033
Far Transfer	-3.061	P= ,0022
Total	-3.059	P= ,0022

Table 9 – Statistical analysis from pre to post-test (Wilcoxon signed-rank)

All subjects mentioned that learning through the hyperdocument was fun. The author stresses the importance of the games as they keep users' interest in the content so as to get good scores.

Marques & Carvalho (2004)

The study carried out by Marques & Carvalho (2004) applied the principles of cognitive flexibility theory to the module "Computers Architecture" (fig. 5) to undergraduate students.

Figure 5 – Mini-case of the Case "Buying a personal computer"

Eight themes were identified and three cases developed whose stories are based on daily problems (table 10).

Cases	Mini-Cases	Context	What to do	Thematic commentaries
Buying a personal computer	3	2	0	12
Updating computing equipment	2	1	0	10
Everyday problems	3	2	3	8

Table 10 - Components of the deconstruction process according to Cognitive Flexibility Theory

This quasi-experimental study compared results achieved through an hyperdocument structured according to CFT (CFT) with another one (Exercises) with exercises about the content (fig 6).
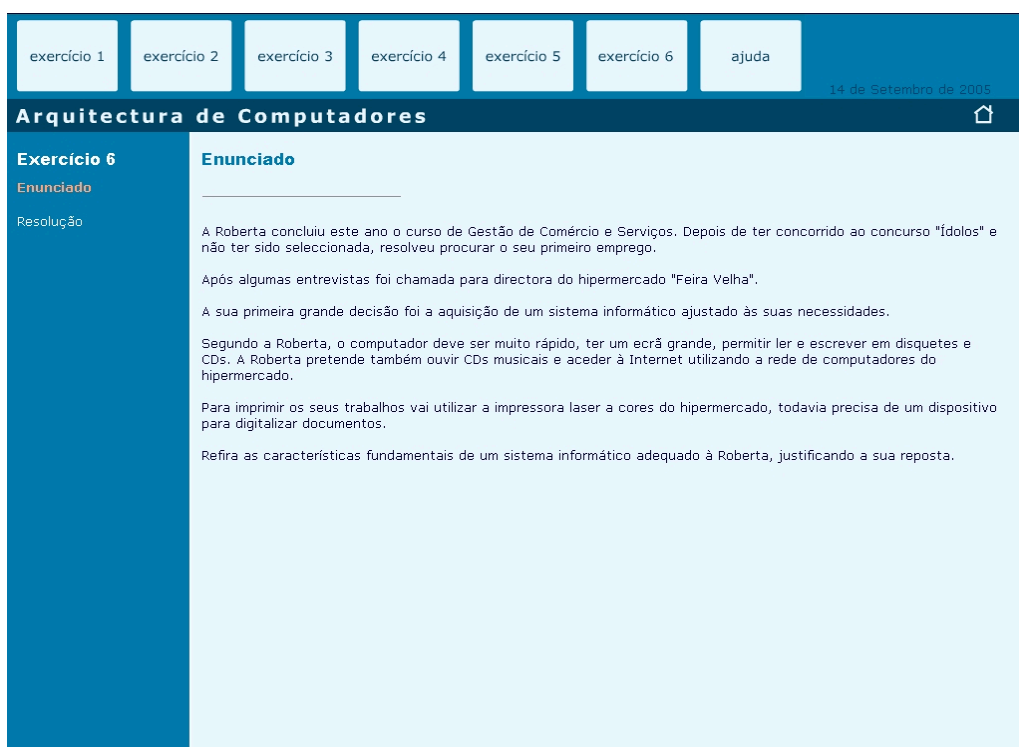

Figure 6 – Hypertext with Exercises

The sample integrated 82 freshman at the Instituto Politécnico of Tomar, in the academic year of 2003-2004.

After doing the pre-test, students explored the hyperdocuments - 37 CFT and 45 Exercises.

Results obtained in pre-test did not show statistically significant differences (p=.096). The groups were equivalent (table 11), apart from the better results obtained by the group Exercises and the greater standard deviation.

Test	Statistic	CFT (n=37)	Exercises (n=45)
Pre-Test	Mean	4,05	4,80
	Standard Deviation	1,727	2,191
	Statistical significance	P=.096	
Post-Test	Mean	12,24	10,13
	Standard Deviation	3,524	3,006
	Statistical significance	P=.0044	

Table 11 - Results obtained by the two groups in the pre- and post-test (N=82)

Post-test results gave evidence to group CFT (table 11). According to t-test results, statistically significant differences (p=.0044) were obtained between groups CFT and Exercises.

All subjects from group CFT considered that thematic commentaries are worthy and most of them referred the importance of thematic criss-crossing in learning.

At the end of the study, the group Exercises explored the hyperdocument provided to CFT and most of the subjects (84%) mentioned that this hyperdocument helped them better face problematic situations.

This study gives evidence that supports cognitive flexibility principles. Moreover, users recognised their contribution to learning.

Marques & Carvalho (2005)

Based on results obtained in Marques & Carvalho (2004) and Carvalho & Pereira (2003), this study used the hyperdocument "Computers Architecture" referred to in Marques & Carvalho (2004) and compared achievement and user opinion with an hyperdocument with deconstruction process and questions in a Forum (to be answered by students and commented by the teacher), instead of thematic criss-crossings.

The study is a quasi-experimental one with two groups. The groups got the same name as the hyperdocument they used. For instance, group D&T (Deconstruction and Thematic criss-crossing - Fig.7) explored the hyperdocument CFT and the group D&F (Deconstruction & Forum) explored the hyperdocument with deconstruction and had access to questions on the forum.

The sample integrated thirty subjects, fifteen for each group, at the Instituto Politécnico of Tomar, in the academic year of 2004-2005.
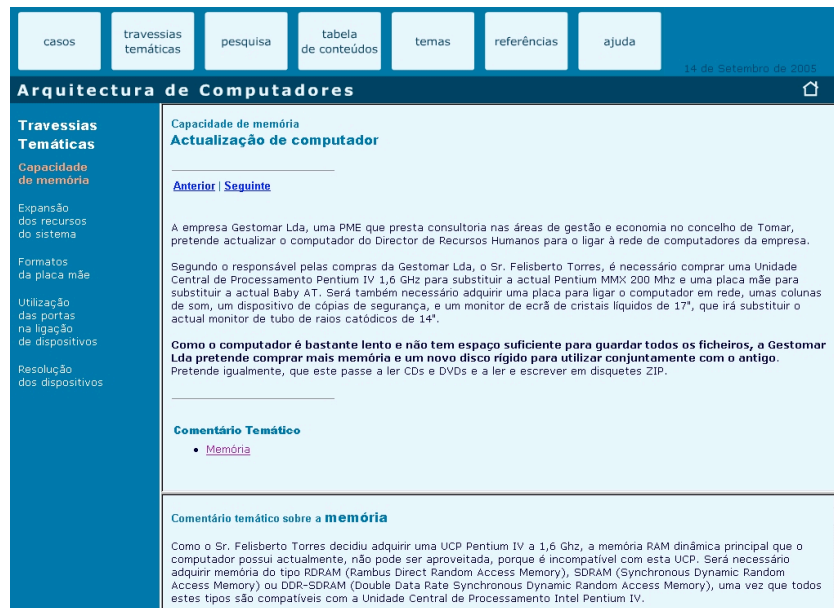
Figure 7 – Thematic criss-crossing of the hyperdocument "Computers Architecture"

Three questions were available in the forum, one at a time. To answer each question, students had to explore the cases. All students answered all three questions and they were very interested in doing this. The teacher had some difficulty in commenting all answers in such a short time.

Pre-test results did not show statistically significant differences (p=.771) - the groups were equivalent (table 12). After exploring their hyperdocument, they answered the post-test. No statistically significant differences (p=.340) were obtained in the post-test results. However, Group D & F had better results (10,5), which means that students got more involved in learning.

Test	Statistic	Group D&T (n=15)	Group D&F (n=15)
Pré-Test	Mean	5,8	5,8
	Standard Deviation	3,5	2,5
	Statistical significance (Wilcoxon Signed Rank)	p=0,771	
Post-Test	Mean	9,5	10,5
	Standard Deviation	3,9	3,3
	Statistical significance (Wilcoxon Signed Rank)	p=0,340	
Pre-/ Post-Test	Statistical significance (Mann Whitney-U)	p=0,001	p=0,001

Table 12 - Results of both groups in pre- and post-test (N= 30)

This study corroborates the importance of the deconstruction process in learning. Besides the non existence of statistically significant differences in the post-test results, group D&F got better scores, which point out the importance of the involvement of the subjects in the forum.

Moreira, Almeida & Raposo (2005)

Based on DIDAKTOS (Moreira et al, 2001), the platform DidaktosOnLine (Moreira et al., 2005) was developed, under the following objectives:

> 1. to foster the production of hypermedia didactic materials by means of collaboration between teachers from common areas and interests;
>
> 2. to make universally available the didactic materials produced on the platform;
>
> 3. to foster the collaborative sharing of these materials among learning communities that share the same interests;
>
> 4. to develop mechanisms of production of e-portfolios for the collaborative construction of knowledge among communities of teachers and students;
>
> 5. to foster the development of teaching and learning communities, through the sharing of materials and to promote contacts among all users of the platform;
>
> 6. to establish the necessary conditions for the distributed education of teachers under the principles of CFT, random access instruction and case-based education.

From the objective of promoting activities of collaborative knowledge construction, e-portfolios result not only from the digital resources but also from the cases developed. They will assume a group character when resulting from team work, or an individual character when produced by a single user. Figure 8 shows the first page of a case, with the possibility of accessing each of the scenes that compose the case. The column to the right shows other contributions of the same author to the platform, taking up the form of individual e-portfolios.

Given that CFT and its principles are not easy to master, a set of teacher education activities (distance and face to face) are being prepared for the potential users of DidaktosOnLine, whose aim consists of endowing them with the competences and skills required for the full adoption of the platform.

Figure 8 – First page of a case, with the list of the author's cases to the right.

Studies will be conducted to assess its impact, both on the collaborative work developed by teachers and students, and also on the interactions developed within the scope of the constitution and maintenance of communities of professional (teaching) practice.

Pedro (ongoing)

Pedro's study deals with the problem of how novice and expert language teachers plan didactic contents with cognitive flexibility hypertexts. The study started in 1999 within the scope of a PhD project and aims at finding how teachers with different degrees of experience select, manage and organize information when planning didactic sequences, using BARTHES (Moreira et al, 2000), a cognitive flexibility hypertext.

The fact that hypermedia systems constitute a present day metaphor for the multidimensionality of the world and of knowledge and, in some way, the fact that they facilitate the representations one makes of knowledge, a new role is therefore reserved for the teacher. For an effective integration of ICT in the educational system, besides an adequate and sound teacher education component, teachers will also have to change their attitudes. Such transformation involves shifting the concept of teachers as knowledge transmitters to one of acceptance of diverse modes of learning, based on non linear structures, completely different from the sequential nature of traditional knowledge.

Research questions in this study relate to new ways of embracing teaching and learning and the adoption of new tools and strategies and aims at finding effective contributions for teaching education: Are there any patterns of management, selection and organisation of contents in the planning activity through cognitive flexibility hypertexts? Are there any differences as to the previous question regarding levels of teaching expertise? To what degree do teachers' individual characteristics influence the

use of these tools? Are cognitive flexibility hypertexts valid and effective in the production/planning of teaching materials?

So far, and as would be expected, preliminary results tend to offer positive answers to the first two research questions - (i) more experienced teachers rely less on course-book materials than less experienced ones and are therefore less confined to the suggestions and structuring of the contents proposed by the course-books; (ii) more experienced teachers are more creative and more didactically informed in their options than their inexperienced colleagues. As to the third one, data still needs to be worked on but one can already assert that cognitive flexibility hypertexts are valid and effective tools for the production and planning of teaching materials. However, a problem still remains: they are time consuming, increasing the work load of teachers both in terms of the time they need to master the theory and also in the use of the tool itself.

The study lacks confirmation of effectiveness of materials developed with their respective target students, an issue that falls aside the concerns of this research project but that would nevertheless enrich its findings.

Conclusion

Cognitive Flexibility Theory has been applied in Portugal to different subject matters such as the management of errors that occur in classroom situations of English as a Foreign language (Moreira, 1996), a novel (Carvalho, 1998; Carvalho & Dias, 2000); grammar – present perfect (Fonseca, 2000), a short story – extensive reading material (Magalhães, 2002), Latin, language and culture (Carvalho & Pereira, 2003), computers architecture (Marques, 2003; Marques & Carvalho, 2004; Marques & Carvalho, 2005), and the environment (Sousa, 2004).

The target audience of the hypertexts developed is diverse - primary school (Sousa, 2004), secondary education (Magalhães, 2002), but most of the studies focus on undergraduate students (Moreira, 1996; Carvalho, 1998; Carvalho & Dias, 2000; Fonseca, 2000; Carvalho & Pereira, 2003; Marques & Carvalho, 2004, and Marques & Carvalho, 2005).

The research conducted evaluated the CFT itself in learning – thematic commentaries and thematic criss-crossing (Carvalho, 1998), compared the results achieved with the deconstruction process *versus* thematic criss-crossing (Moreira, 1996; Fonseca 2000), analysed the implications of CFT principles in learning (Magalhães, 2002; Sousa, 2004), compared CFT principles to another hypertext (Marques & Carvalho, 2004). Other studies maintained the deconstruction process and replaced the thematic criss-crossing for a more active involvement of the learner through questions in a forum (Carvalho & Pereira, 2003) and compared results with CFT hypertext (Marques & Carvalho, 2005). Another research study in progress focuses on how novice and expert language teachers plan didactic contents with cognitive flexibility hypertexts (Pedro, ongoing).

Learning results made salient statistically significant differences from pre- to post-tests in the groups (Carvalho, 1998; Carvalho & Dias, 2000; Carvalho & Pereira, 2003; Sousa, 2004; Marques & Carvalho, 2004; Marques & Carvalho, 2005) where learning a subject according to CFT principles occurred.

When comparing CFT hypertext with another hypertext with exercises, results showed better marks to the group that explored CFT hypertext, and statistically significant differences were observed (Marques & Carvalho, 2004).

Having analysed the importance of thematic commentaries and of thematic criss-crossing in learning, results showed the importance of thematic commentaries –in the deconstruction process and in the thematic criss-crossing - with statistically significant differences (Carvalho, 1998). Even when comparing CFT hypertext (deconstruction process and thematic criss-crossings) with deconstruction and the title only of the thematic criss-crossings, better results were achieved by the group that explore CFT hypertext, but with no statistically significant differences.

When comparing both processes of CFT – deconstruction *versus* thematic criss-crossing - better results were achieved by the group who explore thematic criss-crossings *(*Moreira,1996; Afonso, 2000).

When comparing CFT hypertexts explored individually or in a collaborative way, better results were obtained by the group who works collaboratively (Magalhães, 2002).

Finally, when comparing CFT hypertext with another hypertext with deconstruction and the forum – that replaces the pre-defined thematic criss-crossing - to get students involved in a proactive learning, as designed by Carvalho (2001), better results were achieved with this last structure, and most of the students preferred this version (Marques & Carvalho, 2005).

To facilitate the application of CFT a shell – BARTHES - was developed (Moreira et al., 2000), and to take advantage of the access online, of communication, collaborative work and reusability of materials, two web platforms were developed FleXml (Carvalho et al., 2002) and DidaktosOnLine (Moreira et al., 2005). FleXml gives emphasis to the deconstruction process and to collaborative learning, through chat and forum. The forum should be used to challenge students to think about the content, establishing dynamic criss-crossings to answer the questions put in the forum.

Issues that still need to be addressed involve longitudinal studies about the stages of knowledge development of students who use cognitive flexibility hypertexts, namely in the form of electronic portfolios, and how collaboration in online learning environments that follow CFT principles improves learning outcomes. The social, motivational and attitudinal changes produced by such environments should also be tackled, as well as the design of strategies that may eliminate CFT's less positive facets, and namely the boredom associated with the non-replicated repetition of information, or the passive nature of interaction with content materials, both so characteristic of cognitive flexibility hypertexts.

Other studies that deal with the use of these hypertexts with different technologies – for example with interactive white boards, or even mobile technologies – is also worth looking into: what are the effects of cognitive flexibility hypertexts, usually produced for individual use, when used in class for the whole group or in mobile learning? Will they be effective for teaching, learning and knowledge construction?

These and other issues are just a part of what can and should be done in this field of research. And judging by the studies presented above, this CFT community will continue to go deeper into the benefits of a theory that, although dealing with complexity, is in itself the sheer example of simplicity.

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