

CALL: a strange attractor in language education in South America
Vera Menezes (UFMG)

Good morning! First of all, I would like to thank the WorldCall organization for inviting me to be here today representing South America. I am honored and delighted to be in Fukuoka and to visit this beautiful country.

In my presentation I intend to use the concepts of complexity and chaos as metaphors to discuss computer assisted language learning as a component of education understood as a dynamic complex system.

Before going ahead, we need to define what a dynamic complex system is. A dynamic complex system is one whose components or agents interact among themselves. It changes over time and exhibits emergent properties.

Kaput et al highlight that “The educational systems of advanced societies are highly complex, consisting of many components that interact at multiple layers of organization and at different time-scales.”

Some of these components or agents are: policy-makers, schools, teachers, students, research, technology, the social system and everything it entails (the economy, political organization, culture, etc.). All these agents are dynamically interconnected and the system is much bigger than the sum of its parts because of what emerges from the interrelations among the agents of the system.

In a country like mine, Brazil, educational policies are found in multiple layers: national, state, municipal as well as school policies. They influence and are influenced by each other and they interfere in the several agents of the system. As far as language learning is concerned, in one state one may find recommendations to focus mainly on reading skills and, in another, teachers are urged to work with multimodality and critical literacy. São

Paulo for instance is a very influential state and national economical and educational decisions are highly influenced by that state.

Students and teachers are also distributed among the multiple layers of the educational organization, from kindergarten to university and they are influenced and also influence the other agents of the system.

In South America, the social system is very stratified with a population made up of very poor people, a middle class and very rich people. Besides that, there are the indigenous populations with their own culture. As a consequence, there are also multiple layers of educational quality, of educational facilities and technology. There are schools where books are still not available for the students and schools where each student owns a laptop.

But, the social system is also a complex one and as such it is in constant evolution and inequality can move the system towards more interesting behaviors. If access to technology is limited to the rich class, the whole system is affected and initiatives to overcome inequalities are taken by researchers, teachers, politicians, and administrators. A good example is Negroponte's one laptop per child project¹ and the many efforts of the South American countries to make computers available to every student.

Complex systems are always changing. Society changes and so does language education. In the agrarian age, we had home education in the form of tutoring. In the industrial age, schools followed the factory model, and in language education, we had the boom of labs. In the information age, education is influenced by global models and the school walls can be metaphorically demolished. Communities of practice have been created and network projects offer the language learners the chance to use the language by interacting with other language users in different parts of the world. One example is the Ibunka project which will be presented tomorrow by Mr. Wata and his partners. I myself had the honor to be part of that in 2005 with a group of Brazilian students.

¹ (OLPC)

Complex systems are open, that is, they are far from equilibrium. Educational systems exchange information with the context; they influence the context and are influenced by it. One example is innovation. Language education is open to innovations, such as new learning and acquisition theories, new pedagogical models, and new technologies. In a metaphorical way, innovations can be considered as a kind of energy which moves the system to different routes. Innovations cause disequilibrium in the system and disequilibrium is a necessary condition for the development of a system.

If we take a look at the history of technology we can find out how it has been impacting the dynamics of language learning since the creation of written technology. Technology has been a necessary element in language education since the volumen, a scroll of papyrus, to codex, a collection of sheets attached at the back, whose format, is still found in the books, the way we know them now.

I guess the history of computer in education, not only in South America, but in the whole world, is very similar to the history of the book.

The socialization of the written technology was not a simple process. The book faced the same problems computers face nowadays. The codex was expensive and just a few had the privilege to own one.

Gutenberg's design of metal movable type, the press, represented the first technological revolution in language education. According to Kelly (1969:258) "in the ancient world, books were scarce, cumbersome, and difficult to produce. Booksellers had them copied by slaves, one reader dictating to a roomful of scribes." Books were very expensive and both teacher and the book belonged to the student. Kelly adds that "the only text in the medieval classroom was in the hands of the teacher, the pupils taking down both the text and comments from dictation". According to Kelly, the first register of a book aiming at self-teaching dates back to 1578, when Cardinal Bellarmine published a Hebrew grammar so that learners could study without the help of a teacher.

The first illustrated book, the *Orbis Sensualium Pictus*, was published by Comenius in 1658. This “world in pictures” for children, a very expensive one, presented vocabulary about the nature, the animals, men, jobs, etc. Its objective was to teach nouns in Latin by means of associations with the pictures. Comenius defended the use of books in the classroom, but educators such as Lambert Sauver wanted them to be forbidden in the classrooms. According to Kelly (1969, p.261), Sauver’s advice was: “Give your pupils the book to read at home, as a preparation for your teaching, but forbid them to open it in the class; their ears alone must be occupied there. Not very far from now, during the audio visual period, the students were also forbidden to open the books during the oral tasks.

In 1878, the gramophone was invented and the first audio material for language learning was produced in the very beginning of the last century, by linguaphone. In the picture, we can see a photograph of Roston’s family reading the material while listening to the recorded input. They used this photograph to illustrate their products.

Visual and sound technologies kept being aggregated to language learning. In the thirties, cartoons to teach basic English were produced by Walt Disney Studios and in the forties the same studios used actors for the March of Times series, but such sophisticated technology was not popular at all in South America.

Also in the forties, tape recorders were introduced in schools and mainly in foreign language classrooms. The war context had a huge impact on language teaching. Alexander (2007) informs us that the US Army used the audio-lingual method as early as 1942 and by the 1950s language labs began to emerge and progressive universities developed tape-recorded language-learning materials.

Labs were so powerful in the sixties that a National Association for Language Lab Directors (NALLD) was created in USA in 1965. In 1981, it became IALL (International Association for Learning Labs) and the name evolved to International Association for Language Learning Technology in the early 1990s. Calico, EuroCALL, and TESOL are among the recognized affiliates with IALLT.

Alexander (2007) lists other technologies which became part of the educational system: portable radios, stereo LPs, compact audiocassettes, tape-recorders, portable music players.

In South America, the old audio labs with isolated cabins were replaced by computer labs before all the schools had got its traditional lab.

Computers brought together all the previous gadgets: typewriter, pens, pencils, mail, tape recorder, notebook, book, slide projector, video, cinema, radio, TV, lab material, films, telephone, fax, printer, CD and DVD players, overhead projectors, etc.

Now let's turn our eyes to South America, a continent made up of 13 countries.

Brazil is the largest country in the continent. Its population represents half of the continent.

South America was mainly exploited by Spain and Portugal, although England, the Netherlands and France had also their small share in our colonization. Four languages are spoken in our continent. As Portuguese is spoken only in Brazil, we can say that half of the population of South America speaks Portuguese.

Spanish is spoken in 9 countries (Colombia, Argentina, Peru, Venezuela, Chile, Ecuador, Bolivia, Paraguay and Uruguay). English is spoken in Falkland Islands, an archipelago in the South Atlantic Ocean, located 300 miles from the coast of Argentina and in Guyana, which achieved independence from the United Kingdom in 1966 and became a republic in 1970. Guyana remains as a member of the Commonwealth. French is spoken in the French Guiana, an overseas department of France; and Dutch is spoken in Surinam, a previous Dutch colony which became independent in 1975.

Learning a foreign language in South America is not an easy task as there are usually few opportunities for learners to interact with speakers of languages other than Spanish and Portuguese. Technology has always been the main element to bridge the distance between learners and speakers of other tongues in our continent. I guess the same happens in other parts of the world.

We can find out in an online data bank² which includes Language Learning Histories from Brazil, Japan, and Finland that narrators usually portray language learning in school as a dull experience which deals with impoverished input and focus mainly on grammar. Leaving aside the ones who mention traveling abroad or having other face to face interactions with foreigners, a phase shift in acquisition is achieved when students have learning experiences outside their schools and increase the rate of exposure to the language by means of cultural artifacts – television, radio, CD and DVD players, movies, magazines, newspapers, music, on-line interaction and other computer activities.

In South America, although personal computers were available in the eighties, the real spread of this new technology only happened with the emergence of the Internet in the 90s. No register of significant experiences with computers can be found before that. But we are experiencing a great shift nowadays.

I will now turn to the history of CALL in Brazil.

As revealed in the studies of Rogers et al (2005) and Chambers and Bax (2006), when an innovation appears, the first attitude is of distrust, fear and rejection, but little by little, new practices are incorporated into the system and a normalization state is achieved. It was not different in Brazil. Going back to the complex system theory, we can rephrase this normalization process in the following way. When a new element enters the system it causes some turbulence and disorganizes the system, but out of disorder or chaos, a new order is achieved and the system self-organizes.

Self-organization is an important characteristic of complex adaptive systems. Out of disorganization emerges a more ordered system. One example is the widespread adoption of new technologies nowadays. In spite of the natural resistances, the computer is now an inseparable part of language education, although in different scales. I dare say that we are still living some period of distrust and turbulence as I will show later.

Brazil was connected to the Internet in 1991 when a national research network - Rede Nacional de Pesquisa (RNP) - was created by our main national research agency -

² AMFALE Project

Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq). This network interconnected several universities and the university teachers started interacting with their peers abroad by means of BBS (*Bulletin Board System*), but public access was only possible in 1994 and, in 1997, we had the WWW as we know it today.

Today, 20 million out of the 40 million Internet users in Brazil do not have computers at home, but they usually go to Lan Houses which are available everywhere, even in poor neighborhoods. Part of this population can also go to Computer Centers supported by the government, but in those centers they can neither play games nor access Orkut.

Let's go back to CALL.

The CALL pioneer in Brazil is Dr Heloisa Collins, from the Catholic University in São Paulo. She developed a distance learning ESP reading course with her MA student, Ana Silvia Ferreira, in 1995, using the *Bulletin Board System*, which depended on a telephone connection. Ferreira (1998) registered this experience in her MA thesis, the first research report on CALL in Brazil. Another English course, *Surfing & Learning*, was prepared by a group coordinated by Dr. Collins and it was offered from 1997 to 2002. From 1999 to 2000 *Surfing & Learning* became a joint project of Catholic University in São Paulo and the provider UOL (Universe online). It was an 8-week course of Basic English for adults who wanted to communicate with other internet users using chat, email and forum. Collins was also responsible for other courses involving not only reading, but also oral skills and most of them were part of a large teacher training program, *Teachers' Links*, supported by the her state government.

Dr Denise Braga has been responsible for the project *Read in Web* since 2000 for graduate students. In 2008, *Read in Web* became a regular course for undergraduates as well. She is also involved in developing critical social awareness through digital literacy practices within the context of higher education in Brazil. Her students develop homepages for peripheral groups and develop hypermedia material in health area to be used in schools for underprivileged students.

Another relevant project has been developed by a pool of teachers in São Paulo as an extra-curricular activity for undergraduate students. It is the *Teletandem Brasil: foreign*

languages for all, a project that aims at providing Brazilian university undergraduate students and university students from around the world with free and democratic access to online cooperative processes of learning and teaching foreign languages. With tandem language learning, each partner is a student for one hour, learning and practising the language from the other partner. Then they switch roles and switch languages.

In the south of Brazil, another pioneer is Vilson Leffa. He developed **ELO** (Electronic Learning Organizer), an authoring system for producing learning activities, with emphasis on language teaching. With **ELO** one can create different kinds of teaching activities, including reading with a built-in dictionary, open-ended questions and so on.

I myself and my group started working with CALL in 1997 teaching undergraduate students at Universidade Federal de Minas Gerais. We were the first ones to include CALL as part of our curriculum activities. We use only free discussion groups, forum and free virtual learning environments (TELEDUC, a Brazilian Virtual learning environment, and Moodle). We have been *Reading and Writing on the Web* using material available on the net and urging the students to interact with other English speakers by email or chat. At first, the classes were in the lab, but since 1999 we have been working with asynchronous online activities. In spite of the expected resistance, from more traditional teachers, we managed to offer several online courses including undergraduate and graduate courses on Applied Linguistics issues.

With the new interaction tools and the FL material published on the web, our students, for the first time, were able to do language activities other than the ones in their textbooks. They could also interact with other speakers by email or chat. The new technology, for the first time, allowed our students to be agents, and not mere repeaters. Language could be used in real social practices.

But, the system is still undergoing turbulence. This year, we moved two steps ahead. The first step was in the first semester when we offered an asynchronous online course on English Reading Strategies for 1,000 undergraduate students who needed to improve their reading skills in English. This month, we will start our second step offering the second level course and will teach two groups of 1,000 students each. We will have a total of 2000

students. It is worth mentioning that the material was developed in a collaborative project involving researchers and collaborators in several Brazilian universities.

This decision caused much distress among some peers and staff. Some of them did not trust the quality of a course for such a huge number of students. Others were afraid of being forced to teach courses like that and a more political group blamed the government for not hiring more teachers so that we could go on teaching just 25 students per class.

In spite of the discomfort felt with the resistance of our peers, others become interested and inspired by our experience. In my university, a colleague devised an academic writing course in Portuguese for 500 students and will start the activities next week.

Rogers et al (2005) explains that “as individuals adopt an innovation, their microbehavior contributes to the macrosystem-level scale of behavior. As the rate of adoption of an innovation accelerates and innovation diffusion takes off, emergent adaptive behavior occurs at the system level.” I guess that was what happened with this Brazilian group of CALL pioneers.

Complex systems are fractals. Fractals are recurrent self-similar patterns that are found at all levels of a system. As Sade (2008: 14) puts it, in a fractal there are “infinite possibilities of internal subdivisions limited by an external area”.

One example of a fractal is the WWW which is made up of infinite connections. Each connection is in fact a smaller version of the whole WWW. The whole WWW is made up of reduced versions of itself. Considering the WWW as a fractal is seeing it as containing many repeated portions of different sizes, but with similar properties. Online CALL is one of its fractals.

As any complex system, educational systems do not behave in a linear way, and small changes in the system can have a major impact in the whole system. As the pioneers for CALL in Brazil worked also with teacher education, their micro experiences contributed to spread CALL in our country. Their works inspired other teachers in different parts of the country, but were also inspired by the pioneers in other parts of the world.

Abandoning a highly structured and teacher centered methodology in favor of a flexible and student-centered approach disturbs the system although both methodologies can perfectly co-exist. We can understand it as bifurcation of the system, “The splitting into two modes of behavior of a system that previously displayed only one mode”. Bifurcation occurs because the system becomes unstable with the introduction of an innovation and all the by-products which come together . The system is then attracted to a new cycle.

A complex nonlinear system converges towards a *strange attractor*. Sade (2008) explains that

The word “attractor” may lead us to think that it is something that attracts, but, as a matter of fact, attractor is defined by Kauffman³ (In: Taylor, 2001, p. 283n.36) as a *term used to describe the relatively long-term behavior toward which a system tends, or a set of points such that all trajectories nearby converge into it*. In other words, attractor can be understood as *repeated series of states – orderly and recurrent patterns of movement* (Taylor, 2001, p. 185) in which the system stabilizes.

As language education is a non-linear system, tendencies may emerge and remain stable over a relatively long time. That is the case of the use of books, but “Creativity, as pointed out by Miller (2004) is an emergent phenomenon patterned by strange attractors, which govern the complexity of information in dynamic flow” Reigeluth (2007) says that “a strange attractor is a kind of fractal that has a powerful influence over the processes and structures that emerge in a system undergoing transformation” and Rogers et al (2005) adds that it is “strange” because it is orderly when it is expected to be random; attractor because it “attracts” or draws order to itself out of seeming chaos”.

Language education has its strange attractors that never settle down into any normal rhythm. New technologies are among those strange attractors. Books, audio and video technology, and now computers are responsible for changes in the system. Small changes in complex systems can result in disproportionately large effects.

Language education is undergoing a creative turbulence with computers. CALL is a strange attractor in South America and it is a fractal in the education system which has been affected by the digital technologies. Reigeluth (2007) explains that

³ KAUFFMAN, S. (1995). *At home in the universe: the search for the Laws of self-organization and complexity*. New York: Oxford University Press.

“Complex system dynamics are the web of causal relationships that influence the behavior of a system at all its various levels. They help us to understand how a change in one part of an educational system is likely to impact the other parts and the outputs of the system, and to understand how a change in one part of an educational system is likely to be impacted by the other parts of the system”.

The butterfly effect

Small changes in the initial condition of a dynamical system may produce large variations in the long term behavior of the system. The idea is that the flapping wings of a butterfly in Brazil may affect a chain of events leading to a tornado in Japan. The impact of computers in education is equivalent to the metaphor of the butterfly effect. Had computers not entered the system, the route of the educational system might have been totally different.

The impact can be felt in diverse elements of the system: educational policies, school, teachers, students, research and technology itself.

I will show some examples of such impact in South America.

One Impact in educacional policies is

Chile ENLACES (*enlaces* means links in Spanish): The project consists of information and communications network among the nation's public primary and secondary schools. The network is called Enlaces (Links), and is a part of the Chilean Government's major educational reform program. Its objective is to improve the quality, efficiency, and equity of primary and secondary education. In 1993, there was a pilot demonstration project in the southern part of the country and by the year 2000, all secondary schools and half of all primary schools had been involved.

Another example is **World Links—A Model for Networked Learning**

In 1997, the World Bank initiated the *World Links* to assist developing countries in bridging the “digital divide. Hawkins (2002) states that “Its principal capacity-building objective is to provide developing country schools and ministries of education with sustainable solutions for mobilizing the necessary technologies, skills, and educational resources to prepare students and teachers to enter the Networked World.” World Links aimed at bridging the gap in skills, knowledge, and educational opportunities between students in industrialized and developing nations, as well as between rich and poor students within developing countries. Among 21 countries in the project, four in South America were included: Brazil, Chile, Colombia, Paraguay and Peru. According to Hawkins (2002: 39), the network linked thousands of students and teachers around the world for collaborative learning and helped ministries of education pilot and learn from this implementation of Networked Learning in schools.

A third example of the impact of computers in education is the initiative of several countries to offer each student and teacher a computer. Peru bought 40,000 notebooks in February and intends to distribute other 210,000 units to primary school children in remote and rural classroom schools throughout this year. In Uruguay, the plan is to finish the delivery of portable personal computers to all primary schoolchildren and teachers in the country in 2009. This is also happening in Brazil. It is worth mentioning that some cities offer free wireless connections for the population.

The impact of computers on research

Researchers are trying to develop cheaper computers and free software. CALL researchers have been investigating collaboration; feedback; interaction; online classrooms; students’ and teacher’s perceptions, digital literacy, etc. Many dissertations and theses have been produced on CALL in our universities.

Several journals on CALL have been created and one example from South America is EC-CALL Journal (Electronic Colombian Computer-Assisted Language Learning Journal).

The impact of computers on schools

Language labs were replaced by computer labs, curricula were reformed and digital literacy became part of it. Digital libraries offer free access to books and lots of free online journals appeared on the web minimizing the cost with books and other publications. In Brazil, for example, 191 federal institutions have free access to 12,365 international journals and 126 databases on different scientific areas.

There was a boom on distance education programmes and in some traditional schools the tendency is the co-existence of traditional courses and computer mediated activities. Online content has been produced in collaborative projects and some of them are sponsored by the governments. One example is our Ingrede and another is La Enciclopedia Virtual Paraguaya, which gathers together content for all the educational levels, including languages.

Free material is available on the net. One example is both the Argentinean E-teaching online and the Effective English.

The impact of computers on teachers

Teachers have been experimenting new ways of teaching. They have been engaged in collaborative activities both for material production, publishing and also for reflection about their practices. Interaction among peers increased and associations were created. One example is the Asociación Venezolana para la Enseñanza y Aprendizaje de Lenguas Mediados por el Computador which started last year. One of its co-founders, Evelyn Izquierdo is among us.

Different communities of practice were created. In Argentina we have the *Edublogger Argento* which hosts educators blogs. One important community which must not be forgotten is the Webheads in Action with teachers from the whole world, including several from South American. Among them, one can find some of the WorldCALL 2008

Scholarship Awardees: Evelyn Izquierdo from Venezuela and Erika Cruvinel and Jennifer Verschoor from Argentina.

Despite the several positive aspects, there are also problems teachers must cope with. Online classes have more students, but the salary is the same. Even in traditional courses, the students go on interacting with teachers after the classes by email, but they are not paid for this extra task. In some universities, teachers have been replaced by tutors and some Teacher Unions are going to court against that.

The impact of computers on students

Autonomous learning is encouraged and the students become authors as they can now publish and have their texts read by different people. They engage in different communities of practice. There are several pages where one can find a partner to interact with. See, for instance, this page from students from Bolivia looking for partners to practice Japanese, Spanish, Chinese, Portuguese and Norwegian.

A second example is Erika Cruvinel's scrapbook project.

“Project Description: Two classes from different countries start creating a scrapbook that represents the students' interests, lifestyles and culture. Each student will take the scrapbook home to express himself through poems, texts, favorite lyrics, a story, drawing, photos, stickers, postcards. In summary, each student will have a chance to personalize a page. On a set date, the two classes send the scrapbooks to its partner country. The project aims to encourage authentic writing by providing the students with a real audience. Besides, it gives an opportunity for students to understand other cultures. The two classes will exchange e-mails or use a blog to keep in touch during the project.”

A third example is *Writingmatrix: Engaging collaborative writing through social networking* coordinated by Vance Stevens. with the participation of Nelba Quintana, Rita Zeinstejer, from Argentina and Doris Molero, from Venezuela, and their respective

students.

Conclusion

With online CALL there was a shift from local to global interactions. Learners and teachers in South America are not limited anymore to textbooks and to occasional interactions with other speakers. They have choices: teachers can choose free material to complement their own, they can access newspapers, magazines, videos, games, etc. Students can also choose what to read and with whom to interact mediated by oral or written computer tools.

Sharing and collaborating are key elements in the digital educational world. By sharing and collaborating we offer the necessary conditions for the emergence of a collective intelligence as proposed by Pierre Levy (1994).

For language acquisition, a necessary condition is agency, that is, using the language to do something. In spite of many traditional materials published on the web which do not offer students any chance to engage in authentic linguistic social practice, the learners are autonomous enough to be attracted into strange attractors which offer them the opportunity to be agents of their own learning. Our role as CALL teachers is to “disturb” a zone of stability and provoke the chaos that results in a zone of creativity (edge of chaos) where small changes can occur, creating significant effects on learning processes. In order to do that we must free our students from the school walls and empower them to act in the realm of language social practices.

As pointed out by Davis and Sumara (2006:6), “complex systems embody their histories – they learn – and are thus better described in terms of Darwinian evolution than Newtonian mechanics”. CALL in South America learned with some of you who are here today, you are certainly part of our history. The increased connectivity among CALL specialists has certainly contributed to what we do today. We are nested in the world history of CALL and as so, what I showed today is just a fractal of that history. As fractals are recursive processes, I am sure that the fractal I presented today is the starting point of subsequent, unexpected and creative new phases in the future collective history of CALL.

Similar to nature, CALL is always in the process of becoming and I would like to finish my participation here with the verses of a Brazilian singer/songwriter who, probably inspired by Heraclitus' idea that "everything is in a state of flux" wrote the song "Como uma onda" (Like a wave)

Nothing that once was will ever be
the way it once was.
Everything passes, will always pass.
Life comes in waves like the sea
In an endless coming and going
Everything we see is not
As we saw it a second ago
Everything in the world changes all the time
(...)
Like a wave on the sea
Lulu Santos

Thank you very much.

References

- Alexander, Christopher. (2007) Language Labs: an Overview of the Trends. In Teaching English with Technology. A Journal for Teachers of English. Vol. 7, Issue 3 Retrieved May 15, 2008, from http://www.iatefl.org.pl/call/j_soft29.htm
- Chambers, A. & S. Bax (2006). Making CALL work: Towards normalisation. **System**, 34: 465-479.
- Ferreira, Ana Silvia.(1998) *Interações em Curso de Inglês Instrumental Mediado pelo Computador: Expectativas e Resultados*. Unpublished master's thesis, Pontifical Catholic University of São Paulo, São Paulo, São Paulo, Brazil.
- Hawkins, Robert J. (2002) "Ten Lessons for ICT and Education in the Developing World". In The Global Information Technology Report 2001-2002: Readiness for the Networked World, edited by Soumitra Dutta, Bruno Lanvin and Fiona Pua. Retrieved June 15, 2008, from cyber.law.harvard.edu/itg/libpubs/gitrr2002_ch04.pdf
- Kaput, J., Bar-Yam, Y., Jacobson, M. Jakobsson, E., Lemke, J., Wilensky, U., & Collaborators. *Two Roles for Complex Systems in Education: Mainstream Content and Analytical Tools & Perspectives*, Report to NSF on Project #REC-9980241 Retrieved May 15, 2008, from <http://necsi.net>
- Kauffman, S. (1995). *At home in the universe: the search for the Laws of self-organization and complexity*. New York: Oxford University Press.

Kelly, L.G. (1969) 25 centuries of language teaching. Rowley, Massachusetts: Newbury.

Lévy, Pierre.(1994) *L'intelligence collective. Pour une anthropologie du cyberspace*. (Collective Intelligence) La Découverte: Paris, 1994.

Miller, Iona. (2004) *Edge Artists as 'Strange Attractors'*:a Source of Negentropy in Society. Retrieved June 18, 2008, from <http://www.subcutaneous.org/edge.html>

Reigeluth, C.M. (2008). Chaos theory and the sciences of complexity: Foundations for transforming education. In B. Despres (Ed.), **Systems Thinkers in Action: A Field Guide for Effective Change Leadership in Education**. New York: Rowman & Littlefield. Retrieved July 15, 2008 from www.indiana.edu/~syschang/decaturn/documents/chaos_reigeluth_s2004.pdf

Rogers, Everett M., Medina, Una E., Rivera, Mario A. & Wiley, Cody J. (2005) Complex Adaptive Systems and the Diffusion of Innovations. *The Innovation Journal: The Public Sector Innovation Journal*, Volume 10(3), article 30. Retrieved May, 12 from www.innovation.cc/volumes-issues/rogers-adaptivesystem7final.pdf

Sade, Liliane Assis (2008). Complexity And Identity Reconstruction In Second Language Acquisition. Unpublished manuscript.