



THE COMPLEXITY OF LANGUAGE LEARNING

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This paper takes a complexity theory approach to looking at language learning, an approach that investigates how language learners adapt to and interact with people and their environment. Based on interviews with four graduate students, it shows how complexity theory can help us understand both the situatedness of language learning and also commonalities across contexts by examining language learning through the lenses of emergence, distribution, and embodiment. These lenses underscore the perspective that language learning emerges from unique interactions, is distributed across social networks, and is embodied in individuals. Consequently, this paper concludes that it is not sufficient to study cognitive processes, activities, and situated learning alone; in addition, research must consider how learners' interactions and adaptations are embodied, distributed, and emergent in ecologies of complex systems.

Key Words: language learning, complexity theory, English as a second language, writing

INTRODUCTION

- Two graduate students pick up slang and colloquialisms from e-mail, but another doesn't. Why?
- A graduate student writing her statement of purpose gets advice and suggestions from friends, colleagues, and writing tutors. Who wrote the statement of purpose?
- A young graduate student expresses her rage at a person in e-mail? Why did she not say it face-to-face?

Questions like these are not often addressed by cognitive theories of second language (L2) acquisition. These questions, however, reflect actual events of L2 use by real students, and their answers have pedagogical implications. To investigate these questions and others, it will be helpful to use a complexity

theory approach, one that considers writing and language to be complex systems embedded within other interrelated complex systems.

Our world is teeming with complex systems, such as grasslands, forests, oceans, and immune systems. They are being studied in diverse fields to resolve puzzling phenomena like the weather, evolution, globalization, and “increasing returns” in economics. Its proponents include Nobel laureates such as Kenneth Arrow in economics, Ilya Prigogine in chemistry, and Murray Gell-Mann and Philip Anderson in physics. Before applying complexity theory to language learning,¹ however, let us look at the nature of complex systems.

In complexity theory, a distinction is made between complicated and complex systems. A complicated system is one like a car or plane. Its operation can be understood as the interaction of its parts. In contrast, a complex system cannot be so understood; in fact, its operation cannot be predicted, at least over long periods of time, because the actions of its agents are interlinked and interdependent, thus eliminating simple causal explanations of behavior. Take the weather for example. General weather patterns can be seen, of course, as in seasonal climate changes, but daily weather forecasting is limited to within a week, and it is not unusual for a sunny forecast to fall short of picnickers’ expectations. Predicting learning outcomes successfully has an even more dismal record.

Literature Review

Complexity theory, then, does not deal with prediction, but with explanation. It studies and attempts to explain how complex systems emerge and are maintained. According to Kauffman (1993, 1995), complex systems are composed of agents that interact with and adapt to one another and the environment, co-evolving and self-organizing without any central control. Waldrop (1992) wrote,

Thus, people trying to satisfy their material needs unconsciously organize themselves into an economy through myriad individual acts of buying and selling; it happens without anyone being in charge or consciously planning it. The genes in a developing embryo organize themselves in one way to make a liver cell and in another way to make a muscle cell. ... Atoms search for a minimum energy state by forming chemical bonds with each other,

¹ This paper makes no distinction between the terms language learning and language acquisition.

thereby organizing themselves into structures known as molecules. In every case, groups of agents seeking mutual accommodation and self-consistency somehow manage to transcend themselves, acquiring collective properties such as life, thought, and purpose that they might never have possessed individually. (11)

Schools are no exception. In a typical classroom, students adapt to each other and their teachers through reciprocal interactions. Students use their prior experience to anticipate teacher requirements, adapting when their expectations do not fit the requirements. Likewise, teachers adjust class tasks and activities according to previous and present experiences with their students. Through these interactions and adaptations, a class behavior emerges out of the individual behaviors of the teacher and students, with the former differing from the latter. Although the teacher plays a strong role in influencing student behavior, that influence has limits as we see anomalies, such as lessons that have been successful in the past failing on other occasions.

To better understand such emergence and anomalies, complexity theory has attracted some attention in educational research. Scholars have used it as a framework to investigate teaching and learning (Barab *et al.*, 1999; Davis & Sumara, 1997; Davis, Sumara, & Luce-Kapler, 2000; McAndrew, 1997; Pouravood, 1997), school accountability (O'Day, 2002), educational administration (Griffiths, 1997; Sullivan, 1999; Sungaila, 1990), education communities and systems (Cunningham, 2000; Wertheimer and Zinga, 1998), teacher education (Zellermayer, 2005), and curriculum (Doll, 1989, 1993a, 1993b; Goff, 1998; Fleener, 1999; MacPherson, 1995). In addition, the year 2004 saw the beginning of *Complicity*, an online journal devoted to complexity science and educational research.

In the field of second language research, Larsen-Freeman (1997)'s seminal article "Chaos/Complexity Science and Second Language Acquisition" proposed that complexity theory could help us look anew at second language acquisition by "cast[ing] several enduring SLA conundrums in a new light" (p. 141). Van Lier (1997, 2000) also has incorporated complexity theory into an ecological approach to language learning.

Complexity theory also has potential for shedding new "light" on writing in a second language. Cumming and Riazi (2000) write,

Considerable information now exists describing how people compose in a second language and the features of the texts they produce for single writing tasks, but we have very little

information on how people actually learn to write in second languages or how teaching might influence this. ... For this reason, research within educational programs is necessary not only to account realistically for what occurs in learning and teaching practices but also to help to explain them. (p. 57)

As Cumming and Riazi note, we need an explanatory model. However, although they do consider prior and present instructional practices, they do not fully consider the systems in which individual writers are embedded as they learn how to write. To move to an explanatory model of L2 writing, we need to consider the processes and relationships within systems of writing. One study in L1 composition that took such an approach was conducted by Syverson (1994).

Syverson's research analyzed the writing of three disparate entities—a poet, academics and researchers on an email listserv, and university students in a first-year writing course. She used complexity theory “to take a new look at composition” because

In spite of a vast body of research dating back at least to 1890, in spite of the best intentions of talented instructors, in spite of large-scale institutional commitments to composition programs, and in spite of an unprecedented publishing boom for composition textbooks, manuals, style guides, and anthologies, there is no evidence that students are writing, reading, or thinking better than at any time in the past. What are we missing? (p. 3)

Syverson asserted that one missing item was an appropriate unit of analysis, which she designated as the ecology of “interrelated and interdependent complex systems” (p. 6) in which writers were embedded. To investigate these systems, Syverson used four attributes of complexity theory: emergence, distribution, embodiment, and enaction.

The concept of emergence holds that new structures, activities, texts, and thoughts arise out of the self-organizing of agents. For instance, the advent of e-mail stimulated a new body of literature in rhetorical analysis, organizational communication, classroom pedagogy. The medium of e-mail itself afforded “a new style of writing” (p. 48) that was closer to speech (Maynor, 1994).

Distribution refers to the concept that cognition and other processes extend beyond the skin and are shared across individuals, tools, and environmental structures, as when a blind person taps a cane to navigate or when teachers use the built-in cognition of computer hardware and software to produce

spreadsheets of student performance. Hutchins (1995) showed how the knowledge and skills to sail a Navy ship are distributed among the ship's sailors, tools, and structures.

Embodiment asserts that our actions and thoughts are influenced by physical experience, and cognition is embedded in biological, psychological, and cultural contexts. Our cognition and bodies "are not merely contingently linked in lived cognition; they have also evolved together" (Varela, Thompson, & Rosch, 1991, p. 173). Thus, writing is embodied in the tools used for writing, in one's body and emotions, and in the physical environment. Our hands write more comfortably with fatter pens than thinner ones. When fatigued or in a loud environment, we lose concentration and find it more difficult to write. When relaxed and not under deadlines, our thoughts find their way more easily onto paper.

The embodiment of writing affects the cognition of writing. Take, for example, the choice of writing tool, which lies mostly between keyboard and pen (or pencil). Haas (1989) has shown that writers who use only word processing, in comparison with those who use only pen and paper, plan less overall, conceptually, and during prewriting but do more local and sequential planning—whether expert writer or novice. Although these specific findings may not be as true today with the development of word processing software that incorporates conceptual tools, such as electronic "post-its," the point that the physical nature of the writing tool shapes writing processes remains valid.

"Enaction is the principle that knowledge is the result of an ongoing interpretation that emerges through activities and experiences situated in specific environments" (Syverson, 1994, p. 47). That is, individual and environment influence each other reciprocally, so that an intertwining, spiral process of adaptation occurs across time.

As Syverson noted, these are not the only attributes she could have chosen, but with these four, she was able to show "the irreducibly interdependent, dynamic, and adaptive properties of complex systems of readers, writers, and texts . . . and . . . that there are indeed some regularities across a range of quite different writing situations" (p. 248).

This paper extends Syverson's work into L2 writing and language learning in an attempt to gain a different perspective on and perhaps a better understanding of the processes of learning another language. In particular, it uses three of the four attributes in Syverson's study: distribution, embodiment, and emergence.

METHOD

This study was exploratory and is based upon four open-ended, audiotaped interviews (about four hours total and 62 pages of transcript) with four graduate students: two Turks (one female and one male), one Chinese woman, and one Korean woman. The interviews took place over a period of one week at different places and times.

The first interview took place at Nur's² (a mid-twenty-year-old Turkish female graduate student) efficiency in the early afternoon. While sitting on the floor and drinking traditional Turkish coffee, our mutual American friend Linda arrived, who, when we began the interview, busied herself with a picture puzzle. After I finished, Linda began to ask her own questions for another 20-30 minutes. Then, we turned to more mundane conversation for another two hours.

For the second interview, I met Okan (a Turk in his late twenties) at the central mosque, and after the evening prayer, we drove in his car to the Electrical Engineering (EE) building on campus, arriving at his office (a group office for perhaps 5-10 graduate students filled with computers atop desks) at 9 PM. We sat down at two adjoining desks to begin the interview. During this time and throughout the interview, one other EE graduate student was present and working at a computer, and a second graduate student entered at some time during the one-hour interview. Throughout our conversation, Okan seemed fairly relaxed, so I presume the others did not affect him.

Meeting at the library around 5 PM for the third interview, Jung-Nam (a Korean in her late twenties in the College of Education) and I walked over to the business building, where we found a large empty room and began the interview. Only 30 minutes later, we had to find another room, because some debate people had reserved our room. Going up a floor to the very large group study room (perhaps 60 x 100 feet) on the 4th floor. Only two other people were there, whom we knew and chatted with for a few minutes before going to the very back of the room to interview for another 20 minutes. After finishing, we left with one of those friends for Amy's ice cream.

² All names are pseudonyms.

The last interview with Szu-Ping (an under-30-year-old Chinese woman in the College of Education) took place at 4:00 PM in a group study room in the university library without any interruptions.

As this study attempted to ascertain the value of complexity theory as an explanatory framework, the interviews were initially coded from a grounded theory framework (Strauss & Corbin, 1990), and afterwards, I interpreted the results from a complexity theory perspective,

FINDINGS AND DISCUSSION

These four students write for many reasons. They write to maintain relationships with friends and family. They write, especially through e-mail, to obtain information or advice concerning their schoolwork. Naturally, they write papers for their classes, including theses and dissertations.

In their writing, these students engage in various activities: they write with pen and paper or on a keyboard; they engage in revision and editing; they collaborate; and so on. Interacting with other people and their environment, they adjust their behavior, their writing, through a myriad of local interactions that are distributed, embodied, and emergent.

Distribution

Processes in a complex system are distributed throughout the system. In the case of these four graduate students, their writing knowledge and skills were distributed across a variety of tools, media and individuals. All of them used computers for writing, although Szu-Ping wrote papers first with pen, while Okan definitely preferred computer to pen. They all called upon the expertise of their classmates, professionals, and social communities (cf. Solomon, 1993).

In writing academic papers, they used a wide range of resources. Their first one, of course, was their own internalized knowledge of English and writing strategies. They checked their print writing primarily for correct word use and grammar. Organization was also mentioned: Szu-Ping checked that her topic sentences came first, and Jung-Nam called into play her knowledge of English cultural conventions on essay structure and critiquing.

Szu-Ping So when I make some corrections, I usually make my make my topic sentence put first.

Jung Nam I think it's American writing is more like sandwich style, right? So it's like introduction and conclusion are similar to each other, and then body, you put what you're going to talk about in your discussion in the main section ... But in Korean writing, we we don't do that, we kind of start with the lyrical, sometimes lyrical, sometimes very dramatic just beginning introduction. We don't talk about anything similar to things in the conclusion section ...

Jung Nam I mean in our culture, we're not, we have not been educated to point out the, I mean, to critique what other people would do, what other people suggest to do, propose. ...

As non-native speakers of English, they also accessed native-speaker sources to improve their writing. Okan used dictionaries to find synonyms and reading other articles to get an idea of how to start the beginning of a new paper. All participants used native speakers. As Szu-Ping said, "I think what I can do was quite limited, so I just grab some Americans to help me." Szu-Ping and Nur went to the Learning Skills Center, and Okan sometimes sat down with a fellow native-speaking engineering student for help on papers. Recognizing their lack of contextual knowledge, they used these sources primarily to clarify confusing messages or to replace words with others more appropriate for their context.

Szu-Ping They corrected some some wrong words. Yeah. For me, I didn't, I didn't make many grammar mistakes, but I used the many wrong words.

Szu-Ping And some sentences confuse them, so I guessed I conveyed the wrong information in my paper, so they paraphrased my sentences. ...

Okan So, when I write something, if he feels like he is like confused about what I am trying to tell, then of course this is not a good writing, right, so he tells me okay, what do you want to tell, I mean. Then I explain to him, okay, and he corrects that.

Jung-Nam writing words in the proper context is difficult, the most difficult thing for me, and transition words, those kind of expression I'm not good at, those kind of expressions.

Despite writing skill or language ability, the importance of the message determines the extent to which they access external resources and coordinate them. Nur, who had the best command of English of the four, called upon many native and non-native speakers to write her statement of purpose for admission into a doctoral program, which she considered the most difficult writing she had ever done; as she said, “it was the piece of writing that I did that agonized me the most in my life.” Such a strategy should not be considered peculiar to non-native speakers, however. Most people, native or non-native speaker of English, use as many resources as possible when finding it difficult to express themselves well or when writing an important paper. Consider, for example, the acknowledgements in academic papers and books to see how even seasoned professionals call upon others to improve the presentation of their ideas.

In contrast, e-mail messages are usually of lesser importance, and for this reason, the participants rarely used native speakers to check their e-mail, but simply looked them over themselves before sending them.

Jung Nam Grammatical mistakes or sometimes when I write to professors, I see I'm kind of rude. I'm being rude. I try to be polite, so I kind of check the formality, you know.

Jung Nam But when I write to my friends, I don't usually check the formality, but instead I kind of read if there is any typo or if there is any grammatical mistakes, so, sometimes, but I nowadays I find myself very ignorant of grammatical rules. I used to teach grammar in Korea, and I think I was good at grammar.

Szu-Ping But after I finish the e-mails, I usually will come back to do some maybe grammar corrections and to see if I missed any ideas, I should put them....

Grammar correction seemed to be very important to the above two individuals. All individuals, however, are more polite to their professors than to other recipients in their e-mail. As the importance of the audience increases, so does their checking. Likewise, if the importance of the e-mail message itself increases, then so does asking others for advice:

Nur Well, of course, it depends on the message. But I think e-mail is a, it's the nature of the e-mail, you don't feel the need to [ask others for advice]. As a matter of fact, very interestingly, now that I remember, a friend of mine is, she's going, she's applying, or she

received this information about an internship position in you know a company through e-mail from a friend. And who said, well I have a friend working in this company, and I think they're looking for an intern which you might be interested in, you know, the position and you know and this is the information on the internship, and she e-mails a response to this third person whom she didn't know. And I happened to be there in the lab with her when while she was writing the e-mail, and she was sort of concerned about the formality. For example, we negotiated whether we discussed whether she should say, Dear Mr. Something or Dr. John. . . .

As Nur noted, although the nature of e-mail lends itself to less important messages, it can convey more important ones, and when it does, then asking the advice of others comes into play. "Human reasoners are truly *distributed* cognitive engines: we call on external resources to perform specific computational tasks" (Clark, 1997, pp. 68-69). By using external resources, we make possible what is impossible to do alone; in terms of writing, whether e-mail or print, our distributed cognition enables us to reach a higher level of writing than we could have done alone.

Embodiment

Writing is embodied in the tools used for writing, in one's body and emotions, and in the physical environment. As alluded to above, Szu-Ping hated typing and wrote all her academic papers initially by hand, only later transferring them to a computer. In contrast, Okan wrote everything immediately with the keyboard. Accordingly, we see that when revising, Okan generally edited transition words and moves sentences or sections, whereas Szu-Ping, in addition to sentence-level editing, talked about making her ideas clearer and adding extra ideas. Thus, in line with Haas's (1989) work, the choice of tool affected Okan's and Szu-Ping's approaches to planning.

The physical script influences the language chosen to write e-mail. Turkish uses a Latin-based script, which, despite differences, is similar enough to an English alphabet that Turks e-mail each other in Turkish using an English font. Chinese and Korean fonts, however, are not easily found in the U.S., and they take more time for typing messages, even for Szu-Ping and Jung-Nam, who can type in their native languages. Consequently, they preferred to correspond with their Chinese and Korean friends and family in English if they knew English.

Using English affected their writing. Szu-Ping, for example, said that, although she can easily “get to the point” in Chinese, she must ponder over which words to choose in English in order not to be misunderstood. Of course, this pondering was a result of a smaller vocabulary. Because writing is embodied, using English also affected their emotions and content. Jung-Nam felt it necessary to excuse her writing in English:

[I feel] comfortable about writing in English to my friends in Korea. However, sometimes, I care about what they would think of me. I don't want to look like a person who is showing off her knowledge or mastery of English. This is why I usually let them know in advance that my computer does not have Korean alphabets.

Such feelings can even influence the choice of medium and language, as Jung-Nam continued:

When I am writing to my teachers or friends who are much older than I, I am not as comfortable as I am writing to my friends. English does not have fully developed honorification systems. Therefore, I can sound rude or impolite just by using English. For this reason, I usually avoid writing e-mail in English (I prefer to use snail mail for this group of people). Or, if I have to write e-mail, I tell them in advance that I don't have Korean alphabets on my computer.

In contrast, Nur's emotions led her to choose e-mail in one situation. Enraged at someone, she felt the need to convey her anger through e-mail rather than orally or through a letter. Social constraints motivating her to control what she wanted to say interacted with her desire to release her rage face-to-face, resulting in the choice of e-mail, a medium perceived as highly personal and conversational, yet permitting time to reflect on the words chosen.

See, for example, when you're that angry, when you feel that upset, conversation becomes very dangerous. Because it's right at the moment you do it, it's done, and there's nothing you can do about it. Whereas with e-mail I had always had the text in front of me, and it's not like writing a letter either, because I also wrote letters to the person, but e-mail felt how can I say, I thought he would be much more affected because of the conversational tone of the writing. It would be like making him sit right in front of me and

shouting all those words out loud to him without giving him his turn.

Consequently, our choices and our writing are influenced by our bodies, emotions, and physical environment in many ways.

Emergence

International students, when studying in English-speaking countries, increase the number of their interactions with English through a variety of resources, such as print, e-mail, emerging texts, friends, and professors, which, in turn, leads to emerging vocabulary and an awareness of genre.

Naturally, new academic words emerged in the participants' language through print sources. From reading academic papers, Okan reported learning the word "proliferation." Jung-Nam was becoming more aware of different nuances of "synonyms" for transition words. Undoubtedly, they had learned other words, but they were conscious of these.

Another source contributing to an increase in vernacular language for three of the four participants, small though it was, came through their use of e-mail. Okan had learned "will do." He also used the acronyms ASAP and BTW, and Jung-Nam used ASAP, too. Both Jung-Nam and Szu-Ping used smiley face icons. Interestingly, they both also printed out the e-mail messages of native speakers to study them for slang and colloquialisms, and Szu-Ping incorporated such words as "gosh" and "gee" into her oral language. Quite possibly, the e-mail resource compensated for a lack of conversation with native speakers—not that they never spoke with native speakers, of course, but that it was my impression that they spent most of their time with fellow expatriates.

These increases in vocabulary were rather trivial compared to the emergence of fluency in Nur, which came not through e-mail but through conversation. Why? Her network of friends in the year previous to the interview had come to be mostly English speakers. A year ago, she stated, she would have been able to distinguish her frameworks of writing in English and Turkish. Now, she found she could not make that distinction anymore. Indeed, it had only been within the past year, she said, that she could "feel" in English. Her native-like English seemed to be because her "personal . . . casual, friendly and intimate interactions had become to be in English." Moreover, she was learning lately to be "goofy" in her English writing, "to do things like which would look like you're screaming out loud or you're distorting the intonation."

The contrast in language ability between Nur and the other three was striking. She did come to the U.S. with better conversational skills: she had scored only 10 less than the maximum on the TOEFL (Test of English as a Foreign Language). Even so, her ability to feel English and write “goofily” coincided with the emergence of a large network of English native speakers. It was through her adaptation to an exponential increase in interactions with native speakers and massive academic reading that a native-like ability had emerged. Thus, language ability correlates to a densely distributed network of language resources.

Besides the emergence of a feel for English, Nur showed a keen awareness of genre. She talked about writing formal messages, informal ones, and the flexibility of e-mail—unlike a report or letter—to mix formality and informality, to be professional or personal with the same individual, her master’s advisor:

But still, if I don't feel like writing something very formal, depending on the flexibility of the medium, I can always adjust it to my own mood. I can send a sort of an informal message to my advisor, whereas it wouldn't be possible in a letter. . . . If it's on the e-mail, you can mix it with conversation, personal stuff. Whereas if you write a report to him, it's not a possibility.

If I have something very significant to say to a person, it could be professional, it could be personal . . .

The other participants also had an their awareness of genre and audience, which was well expressed by Szu-Ping:

I think academic writing just want to express my opinions. It doesn't mean there will be any receiver.

For me, I think I will use lots of humor in my e-mail, but in academic writing, I will just behave very seriously, because I'm afraid my teacher will think I'm fooling around.

Yeah, second, I think academic writing, I will put some theories in there to make the teacher think I read something.

But e-mail, I don't have to worry about that. What I need to do just express what I'm thinking, and yeah, it's just very easy.

The distinction between e-mail writing and academic papers is not merely one of printed text, but is embodied in the participants' emotions and personal relationships with others. As Jung-Nam said, e-mail writing is "fun because it's informal and you talk about your personal life, so it's not boring." In contrast, academic writing was seen as "necessary," although in some ways, it was preferred to speaking, because it gave them time to think about what they would say.

The common feelings and awareness of the participants concerning the genres of e-mail and academic papers³ underscored the coordination and adaptation of these individuals to writing systems. Although they likely had written academic papers in their home countries, they had not used e-mail before coming to the U.S. Yet, they had adapted to what was (in)appropriate with e-mail and how it differed from academic papers.

The emergence of their understanding of the e-mail writing system occurred through their daily, local interactions of sending and receiving e-mail, responding to activities and adapting to messages, forming and breaking personal relationships, learning and using e-mail commands, and coordinating all these different interactions with others and with the tools available.

Such emergence of language above mostly pertained to the individual as a complex system. At present, it is difficult to determine how these students' interactions, coordinations, and adaptations had affected the writing ecologies within which they were embedded due to the limited information from the interviews. Nevertheless, it is likely that their interactions with others—friends, classmates, professors—had resulted in co-evolving practices, so that the writing ecologies themselves were adapting and changing, albeit much more slowly.

CONCLUSION

Complexity theory is a powerful tool for investigating writing and language learning in general, and the three attributes of distribution, embodiment, and emergence provide useful lenses for answering the three questions at the beginning of this paper, all of which focused on Nur. The embodiment of language influenced Nur's choice of the medium of email, because it allowed

³ I am using the term genre in a broad sense here, realizing that genres differ across and even within academic disciplines and that the medium of e-mail can incorporate different genres.

her to express her rage. She did not write her statement of purpose alone, but rather a distributed cognitive network did. Her network of English-speaking friends was also instrumental in facilitating the emergence of a native-like fluency through the many interactions in English it provided. That fluency, in turn, likely allowed the few words she might have picked up through email to go by unnoticed in contrast to the other three who lacked such a network so that even a few words learned through that medium stood out.

Complexity theory shows us that no central control or plan for language learning directed these students; rather, locally situated interactions led to the emergence of different writing behaviors within systems of writing, behaviors and systems that were unique for each participant, yet which also held regularities across them:

- They all wrote, but one preferred pen, and another, keyboard.
- They all used native speakers, but only two had gone to the Learning Skills Center.
- They all revised their e-mail very little and their academic papers very much, but some more locally than others.
- They all had improved their English vernacular: some through e-mail, one through conversation; three only a little, one dramatically.

The key to regularities lies in the constraints common to them, some of which are:

- They wrote *to communicate*, whether to friends, family, or professors.
- They used native speakers and revise *to meet the expectations of their professors* (among others).
- They all had improved their vernacular, because *they had encountered conversational communication*.

The uniqueness of each student's learning derived from the history of and the situatedness of their local interactions, which reminds us that regularities regularly have exceptions. For instance, the literature in L1 composition asserts that a major difference between expert and novice writers lies in revision practices (e.g., Sommers, 1980). Novice writers revise locally, focusing on sentence level errors and meaning, whereas experts take a global perspective, restructuring their papers and ideas. With the participants in this study,

however, a more complex picture emerges. Okan, who seemed to be the least proficient in English, revised very little at the sentence level, but restructured his paper by moving sentences and paragraphs into more appropriate places. In contrast, Jung-Nam and Szu-Ping, although they revised globally, seemed to concentrate on grammatical errors. Speculating, I would say that the latter two, who are getting graduate degrees in TESL, have had grammatical correctness drummed into them (cf. Leki, 1995; Hamp-Lyons, 1991), whereas Okan, a member of the engineering community, saw writing more as a necessary chore than as a part of his profession (cf. Winsor, 1989). In other words, the former two's historical and local writing experiences within a TESL community had emerged into revising that contained a strong focus on grammar, while the latter's writing interactions within his local engineering community had emerged into global revising behavior.

The power of complexity theory lies in its ability to explain both the uniqueness of composing situations and also the regularities across them. It does not replace other perspectives, but complements them. It is not enough to study only cognitive processes, activities, and situated learning; we must also understand how people interact with their environment and others, adapt to their interactions, and organize complex systems of behavior.

Just as important as theoretical considerations are the pedagogical implications. With respect to the embodiment of learning, what sorts of changes in the physical environment might we make to promote interaction? With respect to the distributed nature of cognition, might we not take advantage of technology? Technology can help in an English as a foreign language (EFL) context. Unlike the students in the study who encountered English daily, EFL students experience English primarily in the classroom or in their homework. Even for those students in the U.S., the difference between Nur and the other three was multiplied by her new network of English speakers. Online tools, such as social bookmarking, news aggregators in web browsers, and wikis,⁴ can support new *social* networks to facilitate interactions among students and between students

⁴ Social bookmarking is an online activity in which people can mark, categorize, and save web pages and share them with others. The initiator and best well-known of this tool is del.icio.us (<http://del.icio.us>). A news aggregator is software that collects news or postings from regularly updated websites, including online newspapers and weblogs. Many web browsers, e.g., Safari and Firefox, come with a news aggregator. Wikis are websites that let users add and edit content, which is useful for collaborative writing and projects and thus for creating communities. One well-known example is Wikipedia, an online encyclopedia open to the public for adding and editing content.

and others outside the classroom. I have emphasized *social* because much of bringing technology into the classroom has simply been a way to allow students to work on their own rather than a way to engage them in meaningful and authentic communication in the L2. It was a social network, not extra language study that promoted the emergence of fluency in Nur.

Although using only interviews as data along with a small sample size might suggest to some a lack of generalizability to other groups of people, statistical generalization was not a goal of this study. Rather, the goal was to investigate the potential of complexity theory as a tool for understanding better how people learn another language. It is the theory that is extended to other contexts (Yin, 1994). This exploratory study does indicate that second language research can benefit from the insights of complexity theory and should consider the processes of learning to write and learning a language as embedded in ecologies of interrelated and interdependent complex systems.

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