



The Electronic Journal for English as a Second Language

June 2011—Volume 15, Number 1

Classrooms as Complex Adaptive Systems: A Relational Model

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Abstract

In this article, we describe and model the language classroom as a complex adaptive system (see Logan & Schumann, 2005). We argue that linear, categorical descriptions of classroom processes and interactions do not sufficiently explain the complex nature of classrooms, and cannot account for how classroom change occurs (or does not occur), over time. A relational model of classrooms is proposed which focuses on the relations between different elements (physical, environmental, cognitive, social) in the classroom and on how their interaction is crucial in understanding and describing classroom action.

Introduction

Diane Larsen-Freeman's seminal paper (1997) on parallels in chaos/complexity theory and the study of second language acquisition engendered new directions in thinking about language learning processes and caused a re-evaluation among second language acquisition researchers of some of the basic assumptions in the field (e.g., de Bot, Lowie & Verspoor, 2005a, 2005b; Ellis & Larsen-Freeman, 2006; Herdiner & Jessner, 2002; Larsen-Freeman & Cameron, 2007). Larsen-Freeman identified a number of areas where it might be profitable to reconceptualize some of the essential questions raised in SLA and to re-envisage them from the perspectives offered through chaos and complex systems theory in the social sciences. More recently, de Bot *et al.* (2005a, 2005b) have put dynamic systems theory to productive use to explain instability and variability in

the development of language knowledge, according to the nature of the interaction of individual factors (such as age, attitude, motivation, intelligence, early learning experiences), and argue that it is 'impossible to extract and measure single factors that contribute to SLA because they all interact' (2005a, p. 76).

Schneider (1997, 2001) utilizes chaos theory to explain dialect variability and change, arguing that the properties of chaotic systems help to explain the 'alternation between areas or periods of relative stability and areas or periods of "chaotic variability"' (2001) as well as the unpredictability and aperiodicity of language acquisition. Schneider builds on earlier work by Bernadez (1994), Lightfoot (1991) and Wildgen (1982) among others. Looking at language learning from the perspective of human language development, Smith, Brighton & Kirby (2003) argue that Chomskyan innatist and adaptationist models of language fail to explain the development of compositionality, which they see as a fundamental structural property of language acquisition (cf. Ke & Holland, 2006). A theory of language evolution, they argue, requires an understanding of the complex adaptive interactions of biological evolution, learning and culture. Their Iterated Learning Model seeks to demonstrate that compositional language emerges from a "bottleneck" in cultural transmission, which leads to an adaptive breakthrough in language development.

The related theoretical approaches underpinning the studies on language learning and language evolution cited above share a number of features, such as context-sensitivity, interrelatedness among elements, and non-linearity, and a number of discussion papers which consider the relevance of such theories to language education more broadly have also appeared (e.g., Hill, 2003; Hodge, 2003; Mallows, 2002). Yet despite these developments, very few studies have applied such theoretical perspectives to analysing classrooms (though see Finch, 2001; Lemke & Sabelli, 2006; Senior, 2006; van Lier, 1996). In this paper, we present a relational model which we have developed in an attempt to map the complexity of two language classrooms and to account for the changes that we have observed in the teachers' classroom practice, and their thinking about their practice (cf. Feryok, 2010). This model conceptualizes the classroom not as a machine where inputs are processed and outputs generated, not as a space where activity takes place, and not as an activity, but as a convergence of different elements which stretch beyond the temporal and spatial location of a given classroom, and which combine in dynamic relationships.

In presenting this model we build on a number of areas of research within Applied Linguistics, and conceptualize classrooms as complex adaptive systems (see Logan & Schumann, 2005), which comprise 'multiple agents dynamically interacting in fluctuating and combinatory ways' (Rogers *et al.*, 2005, p. 3).

Our aim is to use these concepts as a metaphor (Bowers, 1990; Kramsch, 2002a; Larsen-Freeman, 1997; Larsen-Freeman & Cameron, 2007) to better understand classrooms, and in particular the conditions under which classroom processes might become sensitive to changes in a teacher's thinking. The ultimate aim of such an approach will be to work towards a better understanding of how teacher-educators

might bring about changes in teachers' classroom practice, and a positive change in classrooms overall.

In the following section, we describe the study from which the model presented in this paper developed. Following that, we provide a discussion of relevant research and theory. We then look at data from the study, and outline the classroom model. After considering the limitations of the model, we finally discuss its implications for research on classrooms more broadly.

The study

Our focus in this article is less on the study we describe in this section (which has been reported in Burns & Knox, 2005), and more on the relational model we have developed in our reflection on its implications. Nevertheless, data from the study are presented in the section on 'Modeling the dynamism of the classroom' in order to support and illustrate our contentions. In this section, we aim only to provide sufficient detail about the study to illustrate how the research became the basis for our model.

We researched the classrooms of two teachers, who had completed a unit in a Master of Applied Linguistics program. We co-taught the unit, which focused on systemic functional linguistics (SFL) and its applications to the language classroom over a semester consisting of 26 hours of on-campus classes. The students of the teachers we observed were mostly young adult learners studying in intensive university-based pre-sessional English classes. The aim of the research was to explore i) how and to what extent the theoretical concepts of SFL impacted on the teachers' knowledge about language (KAL); and ii) what impact this knowledge had on their classroom practices. The observations and interviews took place six months after the teachers had completed the unit.

Procedures

The main procedures used in the study were as follows:

1. Before the first observation the teachers were asked to write a brief description of their class. We also asked them to describe their greatest challenge in teaching grammar.
2. Four lessons with each teacher were observed and audio-recorded by the researchers over a period of six weeks. In total eight hours of teaching by each teacher were observed.
3. Immediately before each lesson, the teachers were interviewed briefly and asked to describe their overall goals and any other details about the lesson they wished to clarify. All interviews for the study were audio-recorded.
4. Immediately after each lesson, the teachers were interviewed for up to 30 minutes to obtain their immediate reactions to the lesson.
5. Approximately five days after the first observation, the researchers conducted an hour-long interview with each teacher. A second long interview (90 minutes) was held approximately one month after the subsequent lesson observations,

and transcripts were supplied to the teachers in advance. Parts of the transcripts were used in a stimulated recall procedure during the interviews, where the teachers were asked to comment on specific teaching sequences.

To analyse the data we scanned the classroom and interview transcripts using a continual iterative process to develop major themes and categories (cf. Bogden & Biklen, 1998).

Findings

We focus here on the themes that arose from our observations of the classrooms, the classroom transcripts, and the interview data where the teachers explicated their practices and the factors that influenced and mediated them. Our initial analysis led us to the typology in Table 1.

It was already obvious from the typology in Table 1 that to gain a full appreciation of the nature and processes in the teachers' KAL, it was not enough to consider pedagogical practices in isolation. As the data analysis proceeded it became apparent also that the static and fixed categories of this typology could not adequately reflect the (re-)emergent and shifting nature of the teachers' KAL across the four lesson observations. Their understandings of the theoretical concepts of SFL and how these related to their teaching were in a state of flux, and this instability was clearly related to changes we were observing in their pedagogical practices. In addition, the presence of researchers (who were previously their teachers) in their classrooms, together with the reflexive and conversational nature of the interviews were external factors that were inevitably causing perturbations and pushing existing beliefs and practices into disequilibrium.

Table 1: Typology of factors influencing classroom practices

Institutional	Pedagogical	Personal	Physical
<ul style="list-style-type: none"> ▪ exam pressures ▪ time tabling and time pressures ▪ course aims and syllabus requirements ▪ required materials ▪ course focus on tertiary entry/study ▪ time available for preparation 	<ul style="list-style-type: none"> ▪ previous lesson(s) ▪ student needs ▪ student skills/language ability ▪ newness of student experiences of tertiary study ▪ online classroom decision-making ▪ student age ▪ teacher-student relationships ▪ focus of the research project 	<ul style="list-style-type: none"> ▪ language learning experiences ▪ previous training as (language) teacher ▪ previous teaching experience ▪ existing practices ▪ theories of teaching ▪ theories of learning ▪ recent study (of SFL) ▪ current study commitments ▪ personal lives and relationships 	<ul style="list-style-type: none"> ▪ heat ▪ physical size and layout of class ▪ changes of rooms ▪ student movement in and out of class ▪ presence of researchers in classroom

(source: Burns & Knox, 2005, p. 254)

In order to depict such dynamism we recognised progressively that we needed to be able to map interrelatedness, fluidity and unpredictability, rather than construct distinct, separate and fixed categories. In other words, we needed somehow to capture this kaleidoscopic process holistically rather than in parts. As we did so, we drew on theoretical concepts from a number of strands of research in Applied Linguistics, which we outline in the following section.

Research perspectives on classrooms

We began the research study outlined above with a focus on teachers' KAL and the impact of changes in KAL on classroom practices. Initially, our approach was informed primarily by research into teacher cognition, and to a lesser extent research into classroom discourse.

Studies of language teacher cognition focus on the relationship between teachers' practices and the rationale informing or underlying this practice (see Borg, 2003, 2006). It is a common assumption that teachers must be observed in action in the classroom in order for researchers to make valid claims regarding their decision-making, and many studies bring the social context of teachers' practice into explanations of decision-making (e.g., Burns, 1992, 1996; Burns & Knox, 2005; Breen *et al.*, 2001; Freeman & Johnson, 1998; Johnson, 1996; Richards & Pennington, 1998; Woods, 1996).

Studies which have focused explicitly on the relationship between teacher cognition and teachers' classroom practice have collectively shown that 'language teachers' classroom practices are shaped by a wide range of interacting and often conflicting factors' (Borg 2003, p. 91). Some scholars have concluded that teachers' cognition studies are 'unreliable' (e.g., Basturkmen, Loewen & Ellis, 2004; Tabachnick & Zeichner, 1986) as teachers' beliefs and practices often appear to be contradictory. However, if classrooms are viewed as complex adaptive systems, it can be argued that contradictory research findings are not so much unreliable as reflective of the fact that teachers' understandings of classrooms and their own actions are both context-dependent, and subject to continual re-organisation in interaction with their environment (cf. Borg, 2006).

Our project was also informed by research on classroom discourse, which has become well-established and generated a rich body of empirical work (e.g., Breen, 2001a; Cazden, 2001; Chaudron, 1988; Christie, 1999; Hall & Verplaetse, 2000; Mehan, 1979; Pica, 1987; Sinclair & Coulthard, 1975; van Lier, 2001). Some of this research has connected with the work of sociologists such as Bernstein and Bourdieu, describing ways in which discursive patterns of action and interaction and the social roles of teacher and learner are both reflective and constitutive of the larger structure of the curriculum, and social structures where patterns of wealth and social class are systematically related to educational resources and opportunities (e.g., Breen, 2001a; Christie, 1999, 2002; Lin, 2001; O'Halloran, 2004; van Lier, 1996).

As we observed the changes taking place in the two teachers' classrooms, it became increasingly apparent that these classrooms were not merely the *context* of teacher practice (cognitive and discursive), but were themselves the *phenomena* in which the teachers were playing a part. Existing research findings of connections between teachers' decision-making and social context, and between discursive action and broader social structures, were influential in our decision to draw increasingly on classroom-based research in applied linguistics which has taken a social (and later an 'ecological') turn.

Much of this socially-oriented classroom-based research is strongly grounded in the discursive tradition described above. Breen's (2001b) paper (first published in 1985) draws on the work of Malinowski to describe classrooms as 'coral gardens' – the language class 'is an arena of subjective and intersubjective realities which are worked out, changed, and maintained. ... [These activities] continually specify and mould the activities of teaching and learning' (Breen, 2001b, p. 128). Work by scholars who have taken a social and cultural view of classrooms (e.g., Canagarajah, 2001; Holliday, 1994; Kramsch, 1993) shows how language classrooms can provide a 'third space' for language learners (and teachers) to explore and negotiate their linguistic and social identities (see also Coleman, 1996; Gieve & Miller 2006; Senior, 2006), and has been paralleled by work in sociocultural theory, which takes a Vygotskian perspective on learning and teaching (e.g., Lantolf, 2000; Lantolf & Thorne, 2006).

Researchers who approach classrooms as multifaceted and organic sites of social activity draw on a range of paradigms, including those already discussed, and take what have become known as *ecological perspectives* on classrooms (see Kramsch, 2002b; van Lier, 2000, 2004). Such researchers find:

[I]n the notion of "ecology" a rallying framework to voice the contradictions, the unpredictabilities, and paradoxes that underlie even the most respectable research in language development. By embracing an ecological perspective they do not intend to replace existing metaphors. Instead, ... they seek new ways of conceptualizing the nature of the relationship between the dancer and the dance. (Kramsch, 2002, pp. 4-5)

We found the notions of embracing contradiction and unpredictability, of providing a complementary metaphor, and of reconceptualizing the relations in classrooms to be consistent with what we were observing in our own research, and also consistent with our growing interest in complex adaptive systems, and the potential such a theoretical approach appeared to provide in describing the process of change in the classrooms of the two teachers.

In addition to the research perspectives discussed above, then, the model we present in this paper draws on the notion of complex adaptive systems, which has been applied increasingly in the field of Applied Linguistics (see 'Introduction' above). The features of complex adaptive systems that we focus on here are interaction, emergence, non-linearity, and nestedness.

Complex adaptive systems (language classrooms in the case of this paper) consist of multiple variables that are constantly in *interaction*. As each variable 'affects all the other variables contained in the system and thus also affects itself' (van Geert, 1994, p. 50), the interaction of the variables in the system produces an inherent potential for instability and also, inevitably, change over time. Thus, it is unproductive to isolate individual variables as a way of describing a system. Rather, the trajectory of complex adaptive systems can be best mapped by the description of emergent patterns of behaviour.

Emergent behavior is behaviour in a system which comes as a result of the interactions between different elements of the system, and which cannot be explained by looking at the elements, but must take into account their relations and interaction in situ (see Ellis & Larsen-Freeman, 2006). Thus, the interactions between elements in a complex adaptive system emerge as 'higher-order' patterns of behaviour in a 'larger' system that operates on a different scale (see Lemke, 2000, 2002). Emergent behaviour cannot be predicted by looking at what parts of a system do in isolation, nor by identifying cause and effect relationships between variables.

Another feature of complex adaptive systems is that they develop in a dialectic manner that is sensitive to initial conditions, and changes in systems are *non-linear* and aperiodic. While there may be periods of relative stability, there will also be times when the system becomes disturbed by the appearance of new, typically external, influences, which can push the system in various unpredictable directions.

Finally, complex adaptive systems are *nested*. That is, they are interconnected with other larger macro-systems systems or smaller subsystems (Folke & Folke, 1992). The various systems are themselves dynamic and are in continuous interaction with each other. For example, classrooms are subsystems within a whole school system, which in turn is a subsystem of a state or national educational system. The educational, social, political, and physical variables within a classroom interconnect with those in 'higher' (social-semiotic) and 'lower' (e.g., chemical, physical, and biological) systems and interact with them (Lemke, 2000, 2002).

We found that viewing classrooms as complex adaptive systems was at once consistent with the research in Applied Linguistics on which we had drawn, and helpful in furthering our understanding of classrooms as relational. In closing this section, we adapt a description of dynamic systems theory ('the science of the development of complex systems over time' – De Bot *et al.*, 2005a, p. 116) which resonates with our own perspective on classrooms. Table 2 describes classrooms as complex adaptive systems.

Table 2: Classrooms as complex adaptive systems

de Bot, Lowie & Verspoor (2005a)	Burns & Knox (2005)
Complex systems are sets of interacting variables.	Classrooms are sets of interacting variables.
In many complex systems, the outcome of development over time cannot be predicted ... because the variables that interact keep changing over time.	In many classrooms, the outcome of development over time cannot be predicted ... because the variables that interact keep changing over time.
Dynamic systems are always part of another system, going from submolecular particles to the universe.	Classrooms are always part of another system, going from classroom, to institution, to an entire society.
As they develop over time, dynamic subsystems appear to settle in specific states, which are preferred but unpredictable, so-called 'attractor states.'	As they develop over time, classrooms appear to settle in specific patterns of practice, which are preferred but unpredictable, so-called 'typical classes.'
Systems develop through iterations of simple procedures that are applied over and over again, with the output of the preceding iteration as the input of the next.	Classrooms develop through iterations of simple procedures that are applied over and over again, with the output of preceding iterations as the input of latter ones.
The development of a dynamic system appears to be highly dependent on its beginning state. Minor differences at the beginning can have dramatic consequences in the long run. ...	The development of a classroom appears to be highly dependent on its beginning state. Minor differences at the beginning can have dramatic consequences in the long run. ...
In dynamic systems, changes in one variable have an impact on all other variables that are part of the system: systems are fully interconnected.	In classrooms, changes in one variable have an impact on all other variables that are part of the class: classrooms are fully interconnected.
In natural systems, development is dependent on resources: ... all natural systems will tend to entropy when no additional energy is added to the system.	In classrooms, development is dependent on resources: ... all classrooms will tend to entropy when no additional energy is added to the class.
Systems develop through interaction with their environment and through internal self-reorganisation.	Classrooms develop through interaction with their environment and through internal self-reorganisation.
Because systems are constantly in flow, they will show variation, which makes them sensitive to specific input at a given point in time and some other input at another point in time.	Because classrooms are constantly in flow, they will show variation, which makes them sensitive to specific input at a given point in time and some other input at another point in time.

Modelling the dynamism of the classroom

Throughout the process of our research project, we were faced with a number of factors, some predictable, some unexpected, some difficult to account for. In our first observation with each teacher (coincidentally the last lesson in the first of two courses each taught respectively during the research), neither applied any of the principles of SFL in their grammar instruction. In later lessons, they did so increasingly. There were a number of factors related to the process of change in teaching approaches we observed. For one of the teachers, the difference in the syllabus of the courses she taught was an important factor:

T: We had like a plan already designed for us [in the first course]. ... On that plan it says whatever we have to teach on each day ...

I: So you didn't really have a choice?

T: So in this case, I really didn't have a choice, no. In the other [course], yeah because it's a general English course, ... we have like a framework but it's a very open framework. So you can teach things that are included there but there are so many things that you can decide when to do it, why to do it and how to do it. [1]

Another factor was our own presence in their classrooms, which in various ways 'tipped the scales' in favour of implementing change. In a post-lesson interview, one of the teachers commented: 'because I had to present a lesson to you I put in the work that I probably otherwise wouldn't put in to quite this degree.' Similarly, in the final interview, the other teacher responded to a question on her participation in the research:

I think that it helped me become more ... conscious about or more confident with this new approach, because as I said to you, at the beginning I felt like I really did not know how to put this into practice ... so it helped me see how I could put that into practice

Simultaneously, many other factors which were observed by us and commented on by the teachers were related to the changes we observed (see Table 1). We have documented the process of change over time for these two teachers elsewhere (Burns & Knox, 2005). Here, we look at an extract from the last observed class of one of the teachers. The first lesson we observed (the last of that particular course) had had a grammar focus on phrasal verbs and the possible combinations between certain verbs and prepositions. Her second lesson (with a new class, teaching a new course) looked at cohesion by analysing a text written by one of the students in the class. In the third lesson, she examined conjunction and signposting in a number of model texts in response to problems she had identified in the students' writing. In the final lesson, the focus on grammar in relation to discourse which had been established in the second and third lessons continued.

T: Okay. All right. So what I've done at the back of this sheet the main uses of modals. Have you got that page? Flip it over...Martin have

you got a copy? You've got, oh no, you're copying out your essay. That's alright.

S: [inaudible sentence]

T: Alright. Um okay so it gives you the three possible sort of, three general times. Hi Ivy...ah...right...I can tell everybody's getting tired. They are coming to class more and more slowly ... Okay we'll just go through the modal verbs very quickly. Actually flip that, yeah that side ... So what do we mean by attitude ... 'cos it says here 'attitude to information.' What do we mean by attitude?

[7 secs]

S: [inaudible sentence]

T: A which? Opinion did you say? Sort of yes it's a bit like opinion but it's it's what, how you feel about how you react towards opinion ... Okay so when you're giving information you might use modals to show how certain you are that your information is true, so and these are comments that I've put in here so you must be the only one who did their homework or ... so 'must' gives the ... is anyone listening? Ethel? ... Concentrate. So it's actually very, why do you think we're doing so much on modals right now? [inaudible word]

[7 secs]

T: Why would we be doing, what's the point of doing all this work on modals? ... It's not just to fill in the time. It's not only because Anne and John are here ... Okay think back to your first draft ... of your essay. What was one of the things I wrote a lot on your first draft?

[10 secs]

T: Modals modals modals ... because in academic writing you often can't say something is 100% so. So often when we're giving information even when we're giving opinion we have to use modals. We have to, and sometimes it's it's in the verb form like the 'would' the 'could' the 'might.' Sometimes it's by adding 'perhaps' or 'possibly' because usually you know you can't say 'television is always bad for children' ... you know, it *can* be, you know it *could* have bad effects on children because you can't always say 100%. So so ... Good afternoon, May. So actually we're looking at the back of that sheet for the moment. So so this is why we're doing modals. Because when we're giving information or opinions we often put it with modals to show that there are other possibilities as well. Okay then there is intention. So it tells us, unlike all the other verbs, the other verbs tell us if things are in the past or if things are in the future or if things are happening now or if things ... ah! I will lock the classroom door. People won't be able to come in anymore.

S: I'm sorry I'm late.

T: Okay.

This extract gives an indication of the language focus of the lesson, and also of the nature of the interaction throughout this lesson. The students did not appear to be responsive to the teacher during this lesson, even though the teacher explained to us later that the language focus was chosen:

... because of the exam essay plus the major assignment that they've done that there really needs to be more kind of modulation in their language ... and I think it's one of the major areas of improvement as they're going into this business course, the next course up.

In our observation notes, one of us wrote: 'silent resistance or subversion is hanging in the air.' When we interviewed the teacher immediately after the lesson, she identified a number of factors relevant to the students' attitude towards the lesson, including their age, the fact that they were now near the end of the course, and an incident between her and a student in a previous class where she had confronted the student about plagiarism in an assignment, a confrontation which resulted in a significant conflict and disrupted the entire class. Factors such as cultural differences in teacher and learner roles, and different understandings of what constitutes plagiarism, were obviously relevant to that conflict, and also therefore to the extract above, and were in fact discussed in this context in the post-lesson interview.

Thus, a combination of factors meant that the teacher's careful preparation and planning were negated by the students' agendas, and the lack of responsiveness led to a high level of teacher talk as student responses were very difficult to elicit. When asked how she felt about the lesson, she responded:

T: Flat really! [laughs] Um ... just I mean a sense of disappointment that I couldn't galvanise them more but yeah um ... I just didn't feel frightfully fresh today so it was just

I: one of those days

T: hard to yeah yeah and it's an awkward time like because they've got all these things coming up, they're really preoccupied with that too.

This lesson unfolded according to the interaction among a number of factors, including but not limited to:

- The syllabus (embodying institutional expectations of what was to be learned and taught)
- The materials the teacher had developed (in response to the learners' needs)
- The agendas of the teacher (e.g., preparing the students for assessment and their next course, satisfying the researchers)

- The agendas of the students (e.g., possibly showing displeasure with the teacher, and/or solidarity with the student who had been involved in the conflict in the previous lesson)
- The presence of the researchers.

The challenge we faced was to integrate these different factors into something more coherent and explanatory than Table 1. That is, what we observed was not something that could be explained simply by listing more and more ‘inputs’ to account for an ‘output.’ The social action we witnessed emerged, in real time, from the dynamic relations between factors in the immediate temporal and spatial environment (e.g., the researchers, the students, the materials), and as part of a longer term process in the trajectories of the students, teacher and researchers as individuals with institutional, cultural, and social identities (incorporating, for example, the evolving demands of the curriculum, understandings of language, and experiences of teaching and learning in different social and institutional contexts). In addition to these factors, the physical environment (such as the size and layout of the classroom, light, heat) had been repeatedly observed by us and mentioned by the teachers as impacting on what took place during lessons.

In order to capture this relational perspective on classroom action, we wanted to construct a model by which we could approach the classrooms we observed as confluences of elements and processes. We viewed the classroom not as a ‘machine’ where these various elements are processed, but more as an ‘organism’ characterised by emergent patterns of behaviour which are brought into existence by the dynamic relationship between such elements over time (cf. Kramsch, 2002a). Our attempt to visually represent this way of understanding and describing the classrooms we observed is shown in Figure 1. The arrows indicate that all elements are dynamic, and that these elements of the system can only be properly understood in terms of their interactions and relations with other elements in and beyond the system, and not in isolation. That is, the model is relational.

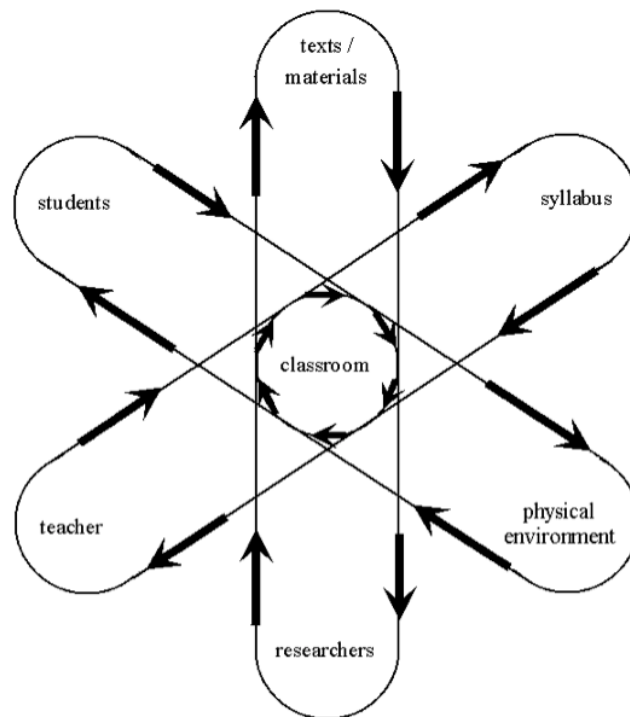


Figure 1: Classroom as a complex adaptive system

In this model, the classroom is seen neither as a space nor an activity, but as a convergence of a number of crucial elements which combine in multiple, dynamic, context-specific relationships. What is captured in this particular description is what came into focus through the lens of our particular research methodology, our questions, and the classrooms we observed. We would expect that studies of other classrooms may identify different elements combining in different ways. That is, while some consistency between classrooms is always to be expected, there will also be individual variation between different classrooms, and in the same classroom over time: we are not claiming that these factors (nor this *combination* of factors) will generalise to every classroom. Thus, the elements in this model are not monolithic, but will be (re)constituted by the particular constraints and variations in context at any given time. In this sense our model is in line with Borg's (2006, p. 275) argument:

The elements which constitute these realities are potentially many, inside the classroom, the school and beyond; some will be temporary (e.g. excessive heat on a particular day), others more permanent (e.g. institutional policy).

Shifting the focus of our model from the classroom to the teacher, we viewed the teachers we observed as social actors playing a particular set of roles in their classroom. Our data identified a number of personal factors that interacted to influence both teachers' action in their classrooms.

For instance, the teacher in the extract above was born in Eastern Europe, and emigrated first to Western Europe and then to a Pacific Island state as a young child, before later moving again to Australia. She raised her experience as an immigrant and a language learner a number of times, on one occasion in relation to student attitudes towards spelling and grammar.

I actually start the patter from the very earliest classes so that they're, they have, 'cos I remember my mother taught me English in [the Pacific Island] and the absolute frustration of wondering where the hell this grammar, well spelling etcetera was coming from. So I think it's sort of, to me it kind of stops people feeling too anxious about it too. About language learning.

In the classroom extract above, her professional development experience and KAL had influenced her decision about what needed to be taught in this particular lesson. Also her own educational experience was important, and she pointed out in the post-lesson interview that she 'felt from [my] own education that nobody had scaffolded stuff enough – it was sit down and write an essay rather than telling you how an essay was constructed.'

Throughout the interviews, both teachers talked about their personal histories, and at times related their moment-to-moment decision-making to experiences distant both spatially and temporally. Personal factors which became apparent from observations and interviews included the teachers' experiences as language learners, their emotional state on a given day at a given time, their teaching experience, their KAL, and their education and professional development. Once again, it was not these elements *per se* that stood out, but the relations between them, and how these relations gelled, shifted, and sometimes dissolved as they interacted with other elements of the classroom.

Using the same modelling principle, we constructed a visual representation of the teachers in the classroom as shown in Figure 2. Again, this representation shows the factors identified in our research; we are not claiming that these are factors which are generalisable to every teacher, nor to every context.

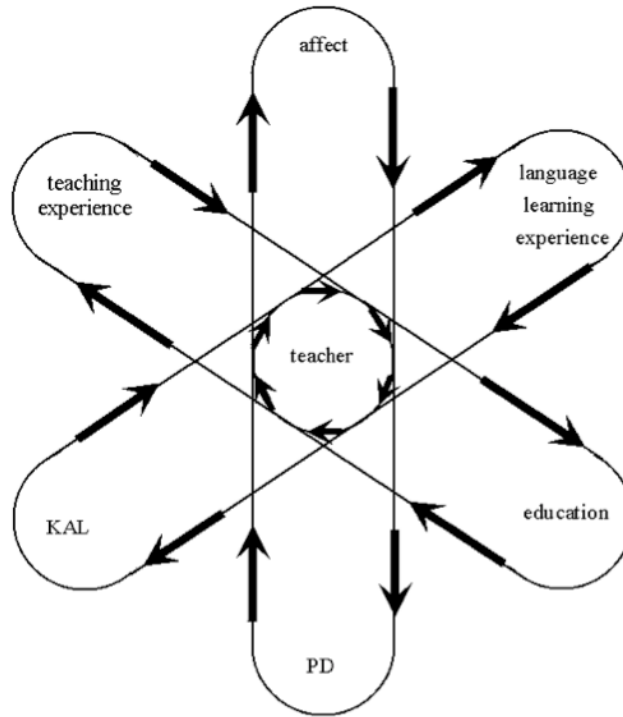


Figure 2: Teacher factors in a relational classroom model

All the lessons we observed took place during a blazing Australian summer, and the impact of the heat on the classroom was tangible. After one lesson where communicative activities had been planned, one teacher commented:

I think that in this case the environment didn't help today. The heat and the weather has affected us because otherwise they're usually really talkative and they're energetic....

In addition, different rooms had different arrangements of furniture, lighting and so on. One of the teachers commented:

It's a very difficult classroom that one. It's very, it was a frustrating classroom, mind you the one here is exactly the same but because everybody has to sit around the edges, it's a very finite limited space. ... in that classroom they're just around the edge so you can't even walk behind them so my one on one was a lot less than it normally would've been in a bigger classroom where I can manoeuvre better and where it's easier to set up tables. I would be much more flexible.

The combination of factors in the physical environment was crucial. Some of the lessons we observed took place in a portable classroom located in a parking lot. The combination of cramped space, intense heat, and relatively poor light produced a physical environment conducive to certain activities (such as perspiring and dozing) and not to others (such as milling activities, role plays, or teacher-learner conferencing). As with the descriptions given above, it was necessary to consider the

relationships between the various factors rather than each one in isolation. A visual representation of the prominent elements in the physical environment through the lens of our research is given in Figure 3.

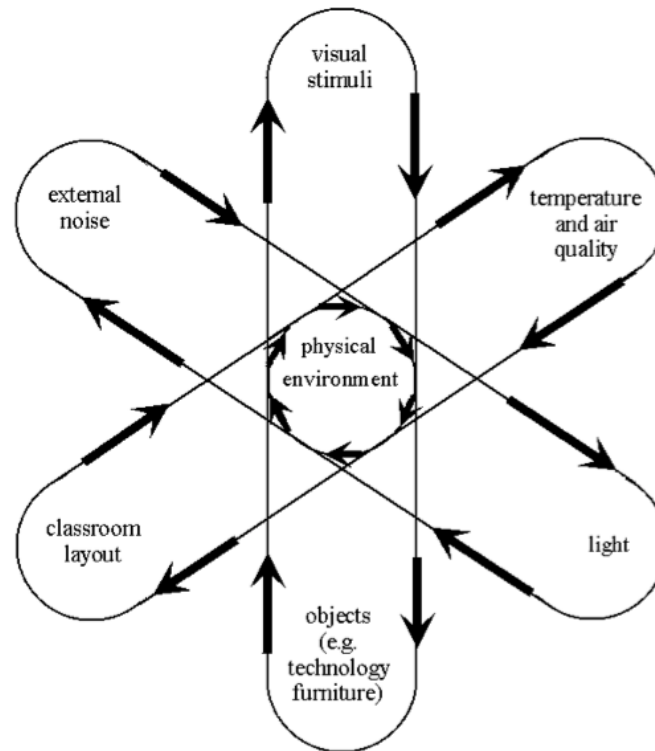


Figure 3: Physical and environmental factors in a relational classroom model

The relational model (and its visual representations) outlined above has enabled us to better understand and account for teacher change in the classroom. Our study began with the aim of exploring the development of two teachers' KAL and its impact on their respective classroom practice. The relational approach described led to our revisiting unquestioned assumptions of 'what a teacher is,' and 'what a classroom is.' As is evident in Figure 2 above, we came to view the two teachers, from the perspective offered by this model, as social actors whose actions could be best understood as emergent behaviours from a range of factors that interact dynamically and continuously. A teacher is a person playing a social role in a particular time and place, and the playing of that role means that certain social and cognitive factors (e.g., KAL, language learning experience, teaching experience) come to the fore as the teacher interacts with other factors in the classroom (such as students, researchers, the physical environment). This is represented visually in Figure 4, which shows how Figures 1-3 combine relationally and visually.

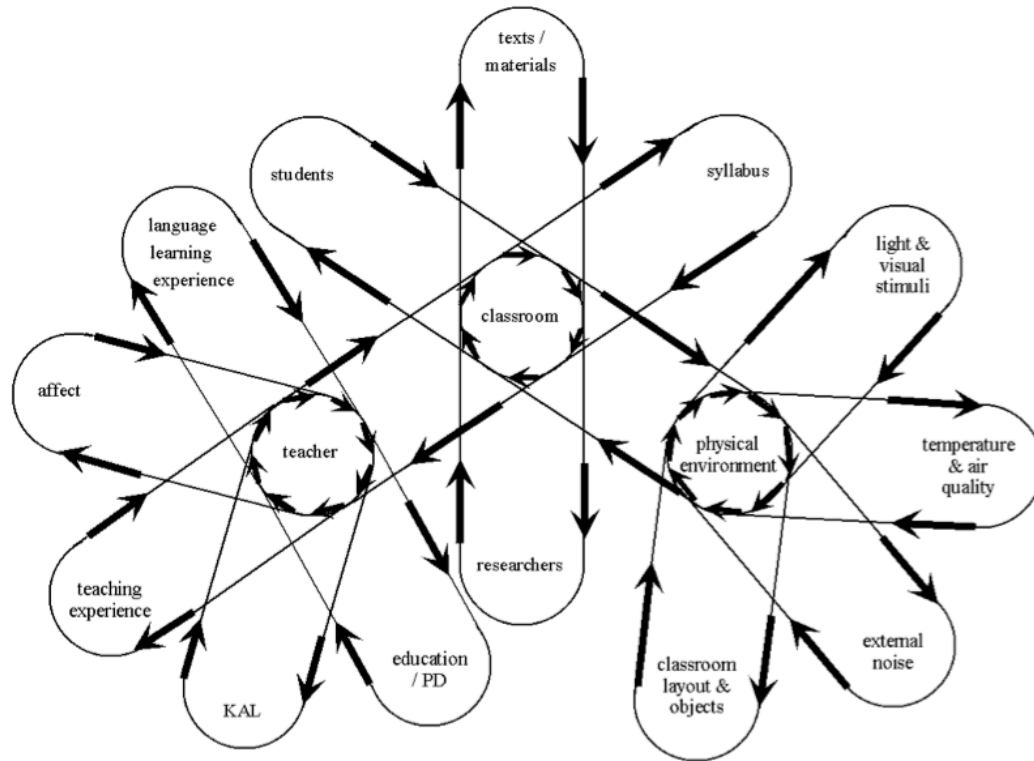


Figure 4: Expansion: Classroom as complex adaptive system

Viewed in this way, the classroom and the action therein is a product of the relations between different elements: some immediate, some distant; some obvious, some hidden; some direct, some indirect. Each element of the model exists in a set of dynamic relations, each of which affects and is affected by other sets of relations in the model. Thus, we can see the classroom as a complex adaptive system, where changes in relations between variables can impact on the entire system. Viewing factors in categorical isolation cannot provide the same descriptive power.

In the case of the classroom extract above, the teacher was (by her own admission) relatively unsuccessful in scaffolding the students into an exploration of the use of modality in academic writing. For future lessons in this classroom, this experience may have had implications for the way that activities were conducted, for student attitudes about this aspect of academic writing, for the amount of lesson preparation this teacher was willing to do, for personal relations between teacher and students, and for many other factors.

Focusing solely on the teacher, this teacher told us during the research that she often develops her understanding of grammar in part by teaching it. Thus, her experience in this lesson seems likely to feed back into her knowledge about this linguistic feature in unpredictable ways (perhaps that it is difficult to teach, difficult for students to understand, or perhaps that it is something she is more determined to teach well and/or learn about). In this way, her KAL is seen not as a static entity residing in her

mind and 'brought into' the classroom, but in constant interaction with the other elements identified in the description in Figure 4.

This perspective on KAL is fundamentally different from that embodied in our original research questions as cited above, which asked firstly how our teaching of SFL impacted on the teachers' KAL, and secondly how changes in KAL affected classroom practice. While these questions do not assume that this research process is simple, nor that it is decontextualised, it nonetheless does presume a linear cause-effect relationship as Figure 5 illustrates.

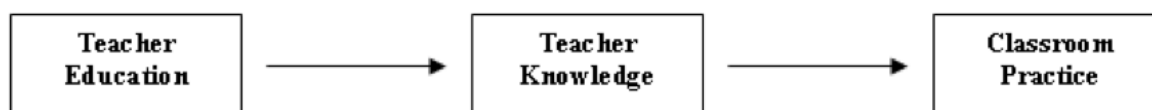


Figure 5: Linear understanding of the relationship between teacher education and classrooms

The limitations in this approach (cf. Figure 4) apply regardless of whether teacher knowledge is language teachers' KAL or subject teachers' subject knowledge, or of whether this knowledge is conceptualised as declarative or procedural knowledge. Knowledge of 'what' and knowledge of 'how to' (if indeed they can be separated) are both relational: teachers' knowledge and classroom practice exist in a complex web of interactions, and classroom practice also impacts on how teachers construct and develop their own knowledge.

This dialectic extends also to classrooms (physical and virtual) where teacher education takes place, and following this research project we incorporated a problem-based approach into our teacher-education course, in which students drew on their own teaching contexts and collectively investigated ways in which SFL could be applied. This is one way in which teachers' professional contexts can be integrated in the teacher education classroom, and the complexity of classrooms can be explored in relation to new subject knowledge.

Conclusions

This paper has presented a relational model of classrooms, drawing on a number of strands of research in and beyond Applied Linguistics. The argument presented is that the model provides a perspective on classrooms which can add to existing research. Nonetheless, this model does have a number of limitations.

The factors identified in the model are a direct product of a particular research focus and methodology. The research project described in this paper relied on classroom observation and interviews with teachers. Other data such as interviews with students, video data, and multimodal analyses of classroom interactions would have yielded greater explanatory power and probably a broader range of relevant factors. This

limitation can be explained in part by the small-scale nature of the study: larger projects with more funding would be able to collect and analyse more data, using a wider range of methodologies, than was possible in this case. Further, the research was not designed to model classrooms, but to investigate language teachers' KAL. The model arose from the research process, and therefore this limitation is also a product of our starting point, and can be addressed by future research which builds on the approach we have outlined here.

As discussed earlier, the classroom is a 'nested' system. In the study described in this paper, the starting point was individual teachers' KAL, which has been modelled here as a factor relevant to the complex adaptive system of the classroom. This raises questions of how best to investigate and model different system levels, and how their interaction can be adequately described. The ways in which classrooms can be modelled in relation to 'higher-order' systems such as institutions, and 'lower-order' systems such as individuals requires considerably more investigation.

Finally, the model attempts to capture the dynamic relationships between different elements which converge in classrooms. However, our two-dimensional visual representation of it is, temporally at least, static. We would liken this to the paradox of viewing light, which can be seen either as particle, or wave, but not both simultaneously. As presented in this paper, the model privileges a 'particle' view of classrooms (Laskowski, 2006 offers a complementary visual representation of the professional development of teachers over time). Constructing visual representations of classroom change over time adds another dimension of complexity, and is likely to require animation, and perhaps three-dimensional graphics. This implies the need to assign numerical values to both the elements in the model and their relations, something which may become possible in future developments (cf. O'Halloran, 2005).

Despite these limitations, this model builds on, and extends existing classroom-based research in Applied Linguistics, and affords a relational view of the classroom in which there is no *a priori* start or end point; classrooms are convergences that reach backwards and forwards temporally, discursively, socially, cognitively, and culturally. Such a view allows us to incorporate a range of factors into our account of action in the classroom, including how an immigrant child's experience of learning English from their mother on a Pacific island can impact on their decision-making decades later in a suburban [location of research] classroom, and how the furniture in that same room, and the attitudes of the students towards a given activity can combine with the teacher's experience and affect, and other factors, to contribute to the success or failure of that activity.

This dynamism is a *typical* feature of classrooms, and means that there is an inherent potential for instability and unpredictability in classrooms, even highly structured, teacher-centred ones where this potential may rarely, if ever be realized. Classroom action can unfold in a relatively predictable manner and in such cases linear methods of description appear to work well (see Hodge, 2003, p. 10). But as with any complex adaptive system, unforeseen (and unidentified) factors can have an unpredictable impact, and when classrooms and the participants in them are in a state of flux, linear

cause-and-effect descriptions cannot comprehensively account for what emerges (see Burns & Knox, 2005; Laskowski, 2006).

Post-experience teacher education aims to add to teachers' knowledge and improve their teaching practice. In a field where in-service teacher education frequently fails to achieve change in teachers' classroom practices (Lamb, 1995; Waters, 2006, p. 33), and where the majority of curriculum innovations flounder over time (Fullan, 1999; Markee, 2001), there is a need for a sound theoretical basis for explaining classroom change, or its lack. Our model suggests that in order to effect change, the work done by teacher educators needs to have sufficient influence on teachers to change the relations between different elements in their classrooms, and that teacher education programs and courses need to be designed and implemented with this important consideration in mind (see Borg, 2003, p. 106).

Helping teachers to develop specific areas of their knowledge and practice (e.g., KAL) may be enough to effect classroom change. However, it is more likely that teachers (and therefore teacher educators) will need to act on a range of classroom variables in order to change the relations and move the classroom productively out of a comfortable state of equilibrium. This implies a need to understand and study classrooms in a way that recognises and accounts for their complexity, rather than one that reduces it.

Occam's razor states that simpler explanations are to be preferred over more complex ones, so long as they account for the data. But the razor is in fact a double-edged sword, since in practice there may be a 'conspiracy' effect between the explanation and the data. The 'simplest explanation that accounts for the data' is applied to data that have been extracted from complex processes because of prior assumptions about their (the data's) significance. Thus the data encourage the 'simplest explanation' and the 'prior assumptions' to become identical. As a result research runs the danger of becoming locked into a reductionism from which it may be hard to break away. (van Lier, 2000, p. 248)

In this short passage, van Lier presents a challenge to 'build in' complexity rather than reduce it. This is a considerable task for classroom researchers, and requires new ways of understanding the phenomena we investigate. The approach outlined in this article represents a metaphor (Kramsch, 2002a) that allowed us to see classrooms in a new light (Bowers, 1990), and to better incorporate the complexity of the classrooms we observed into our analysis and description. We hope others will be able to apply and adapt this metaphor in exploring the complexity of their own sites of investigation.

Acknowledgement

The research on which this paper is based was funded by a Macquarie University Research Grant.

Note

[1] T = teacher; I = interviewer

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