The Complexity of Teacher Learning: Reflection as a Complex Dynamic System

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Abstract
This paper investigates how learning takes place in an intensive post-graduate Second Language Teacher Education (SLTE) course with participants of different backgrounds and experiences. Complexity Science is adopted as the research framework of the study to provide empirical evidence that learning in a teacher education course is a complex, non-linear experience. Through the analysis of reflective journals, the paper argues that although specific objectives and learning outcomes may be identified by course designers, what participants actually learn is highly unpredictable. The data show that the research participants used an elaborate network of links to events, people or places in their past, present, and future in order to create a personal understanding and meaning of the topics discussed during the course. The findings clearly indicate that participants were selective in what they considered important to mention in their reflective journals, although they were exposed to the same educational experience. It is also revealed that their thinking was far from being linear; their thought processes took them on a wild journey across different fields and times, traversing back and forth between past and future. The implications of the study call for the re-structuring of teacher education courses in a way that allows for the natural emergence of learning and models on how complex adaptive systems work. It is argued that teacher education is dominated by standards driven by market forces which seem to ignore and discourage the natural patter of learning. This, unfortunately, may lead to tensions that undermine the validity of teacher education and widen the gap between theory and practice.

Key words: Complexity science, teacher cognition, teacher education, teacher learning

INTRODUCTION
Language teacher education over the past forty years has been characterised by constant change as a result of extensive research into teaching, learning and teacher education. The growing knowledge about how English language teachers go about their everyday work in the classroom, the role of the language learner and instructional materials, and changes in our conceptions of language, language learning, and teacher cognition have
all contributed to a fast developing and transforming profession. In fact, changes in English language teaching and Second Language Teacher Education (SLTE) are so rapid that any notion about teacher education as a ‘traditionalist profession’ which resists change (Andrew, 2005; Sykes, 2008) is probably unjustifiable.

Yet, it is an imperative to understand that while the knowledge-base and delivery of SLTE have gone through various attempts of reconceptualisation, certain key elements are constant and seemingly resistant to change. This duality of change and permanence has created an ‘epistemological gap’ (Johnson, 2006, p. 237) in teacher education programmes which may hinder the further development of the profession. Thus, I believe that it is important to examine how learning takes shape and unfolds in a teacher education course if we are to improve the preparation of future English language teachers. This paper sets out to demonstrate that while SLTE programmes are generally neatly organised, following a systematic structure of linearly arranged stages and clearly ordered content, student teachers’ learning often takes a completely different mode. Learning in a teacher education course is complex, in fact chaotic, which renders it to be investigated through a fairly new research framework in teacher education: Complexity Science.

In this paper I will attempt to offer an insight into how students of a graduate teacher education course work with the course content, collaborate with their peers and tutor to create personal understanding and meaning unique to each and every participant. Empirical data will be used to argue that although SLTE courses have clearly defined aims and objectives, the elaborate learning outcomes which describe what participants will learn and be able to do upon the completion of their studies do not necessarily match with what student teachers actually intake.

**LANGUAGE TEACHING AS A COMPLEX SYSTEM**

The fact that language teaching and teacher education are complex phenomena which are difficult to simplify is now widely recognised (Cochran-Smith, 2003; Freeman, 2007; Holliday, 1999; Johnson, 2006; Kramsch and Ware, 2004; Richards, 2008; Singh and Richards, 2006). This acknowledgement and the rise of complexity science in the 1980s (Gleick, 1987) gave way to new ideologies to examine teaching and how teachers are prepared for their roles in the classroom. Complexity science has now established itself as a framework for educational research and has contributed to research and academic discussion in many ways. But what exactly is complexity science and how would it apply to SLTE programmes?

Many researchers have described and analysed complex systems (Clarke and Collins, 2007; Cochran-Smith, 2003; Davis and Sumara, 2005: 2007; Gleick, 1987; Mamchur and Apps, 2009) and they all agree that these systems can usually be described as having some or all of the following features: (i) sensitivity to initial condition; (ii) unpredictability; (iii) having a nested structure; (iv) showing a non-hierarchic network system; (v) making use of feedback loops; and (vi) emergence or self-organisation.
One of the first descriptions of complex systems can be credited to Edward Lorenz, a meteorologist and mathematician, who set out to model weather changes in the 1950s by using a computer programme. He soon learned that modifying any one of the variables, e.g. temperature, humidity, wind, etc., in his model would lead to a dramatic change in how other elements behaved in his experiment. This led him to the realisation that weather, which is a complex system, is very sensitive to initial condition. He later described this as the butterfly effect (Lorenz, 1969), a metaphor he used to illustrate how a small change in the initial conditions can and probably will have a significant impact on how complex systems evolve and behave. This concept, of course, is very familiar to teachers and teacher educators who are well aware of how a comment from a student, or the learners’ mood, the timing of a lesson, etc. can significantly change the course of learning and teaching. Even the same plan and materials taught by the same teacher can lead to completely different lessons as a result of the existence of initial conditions beyond the control of the educator.

A complex system’s sensitivity to initial conditions is closely connected to its unpredictable nature. Its parts interact with each other and create activities, events and phenomena in a manner which is, although governed by certain rules that apply to the system as a whole, highly unpredictable. There is probably no need to explain how this relates to classrooms and classroom teaching which can “accommodate accidental and deliberate events, both tacit and explicit knowledge, both private and public happenings” (Davis and Sumara, 2007: p. 55). This innate disequilibrium means that how teaching is done and what learning outcomes it produces are both largely unpredictable and are dependent on contextual factors.

Complex systems also reflect a nested structure; they are systems within systems with each level exhibiting the same complexity than that of preceding levels. This structure is often illustrated by fractal geometry where parts are self-similar and each level of magnification will reveal complexities and patterns that are present in its point of origin. As Davis (2003: p. 43) states, “complex phenomena is irreducible. It transcends its parts, and so cannot be studied strictly in term of a compilation of those parts.” One student in a classroom is just as complex as the group she or he works in, or as the class, the year, the school, the school district, etc. where their learning takes place.

Being non-linear, complex systems have a network structure which is non-hierarchic; a complex system grows in all directions and its growth is difficult to control. In education this is acknowledged by social constructivism whereby knowledge is recognised as a social construct, a result of collaborative and shared meaning making of participants. Such a learning environment is based on the principle that participant contribution is a key element of learning, thus it encourages small or large group work for students to discuss and share ideas, consider and synthesise their own and their peers’ ideas, and arrive at deeper levels of understanding. In a learning environment that promotes collaboration, the exchange of knowledge and ideas cannot follow any prescribed manner
or route. It evolves in each and every direction, travels around and bounces back, impacts and modifies its place of origin. This is what complexity science calls feedback-loops.

Finally, an important feature of complex dynamic systems is emergence. It means that at certain times the components or participants of such a system show interaction and collaboration in a form which reveals a structure that governs their existence. This is the point when the parts create something larger than what they constitute individually; a structure which without its individual components and their connectivity would never be realised. This phenomenon is also referred to as self-organisation, an ability and attempt of a complex system to achieve equilibrium in its inherent unpredictability. A good example of such emergence is the concept of a ‘teachable moment’ (Havinghurst, 1952), when conditions at a particular time and in a particular context make learning possible.

**METHODS**

It would be very difficult to illustrate teacher education by using all aspects of complex dynamic systems in a short research paper; therefore the scope of this study is limited to one area only: the network structure of meaning making and learning on a short, intensive graduate SLTE course. The aim of the research is to explore the complexity and non-linearity of learning by mapping out the course participants’ thinking and learning processes, and how these are linked to previous experiences and events in their lives. Thus, the main research question in this qualitative investigation is the following: How do participants on a short, graduate teacher education course use previous experiences to gain personal meanings and understanding of their learning?

**Research Context**

The research was conducted in May, 2010 with five participants who took a joint elective graduate course with the title ‘Program Management and Teacher Development Issues’ as part of their Master of Arts in English Language and Literature Teaching (MA ELLT) and Doctor of Philosophy in English Language and Literature (PhD ELL) studies at the Department of English at the Ateneo de Manila University in the Philippines.

The course followed an intensive programme and was conducted in 10 days (17-28 May, 2010). Each day was divided into two parts: (a) contact hours in the morning for discussion of assigned reading texts and for hands-on practical tasks and activities, and (b) individual reading and reflection tasks in the afternoons. One-to-one consultations with the course tutor were also scheduled for the afternoons twice during the course to address personal doubts, answer, or discuss concerns that the participants may have had.

The five participants were young adults from different parts of the Philippines, with diverse work and life stories. The only link between them was the shared learning experience on the graduate course. In order to protect their identities and ensure their anonymity pseudo names are used when discussing their data: Eszter, Anna, Flora, Jamie, and Bob.
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The participants gave their informed consent in writing which granted permission for the collection and use of their written coursework for research purposes.

Data Collection
The research uses two sources of data: (i) individual reflective journals and (ii) anonymous questions submitted to the tutor at the end of each half-day session. The participants kept a reflective journal to record their ideas in connection with the topics discussed during the course. There were no formal requirements such as word limit or the systematic use of references, which facilitated the elicitation of an informal personal monologue in reaction to the reading texts, the discussions and learning tasks during the course. The journals were collected and were also used as part of the course assessment process.

To supplement the reflective nature of the programme, participants were asked to think of and write at least two questions or comments at the end of each half-day session. These reflected the immediate concerns and ideas that were noted down during the sessions and prompted the participants to be engaged with their own learning processes. As Flora says in her journal:

_This daily questioning has made me more conscious of my thought processes. Every time a question pops into my mind I had to take note of it. I began having an active “relationship” with the text or with what is being discussed._ (Flora, Reflective Journal, Day 2)

Thus, the two sources of data are complementary to each other. The anonymous questions reflect the immediate on-the-spot thinking of participants, whereas the reflective journals allowed students more time for contemplation on their learning and offer an insight into a more carefully mediated thought process. These two processes can be linked to what Schön (1983) calls reflection-in-action and reflection-on-action, where ‘action’ in general terms is understood as the learning process in which the participants were involved. It is also important to note that these processes were not independent of each other; the questions asked at the end of the sessions contributed to how the reflective journals were kept as they may have provided the starting points for each individual entry.

Data Analysis
The data analysis followed the principles of grounded theory research and was conducted as a three stage process. First, a thematic analysis of the journal entries was carried out in order to identify major themes and topics in the course participants’ reflection. This stage focused on the conceptualisation of the data in terms of mapping the individual research participants’ distinctive patterns of thinking. It also allowed the emergence of grounded codes to be used for further analysis since the nature of the data did not lend itself to the use of a priori codes.
The second stage of data analysis was selective coding. The discrete concepts identified during the first stage of analysis, for example ‘learning strategies’ or the ‘view of the self as a learner’ were further scrutinised and attention was directed to specific episodes in the discourse which identified specific and concrete places, people, or institutions. The reason for limiting the focus to these was to delineate abstract thinking and theoretical hypothesis generation from the process of ‘anchoring’ new information or ideas to concrete schema in the brain. This coding offered a clearly traceable pattern for how the process of meaning making unfolded in response to new experiences on the course.

Finally, the last stage of the analysis was axial coding, where the interrelationship of concepts, e.g. such as ‘roles’ and ‘contexts’, were identified. These were also linked to time, differentiating between past, present, and future references. Of course, it was not always possible to draw clear cut boundaries between these three domains as certain concepts seemed to arch over more than one dimension. For example, the use of the present perfect tense in connection with talking about the self in the role of a teacher indicated that the both the past and the present times were addressed and a notion that had started in the past still had validity and actuality for the present when the journal entry was written.

The nodes identified in the final stage of coding were then placed on a multi-dimensional model of concept and time which was able to capture and visualise the complexity and dynamic nature of personal meaning making as it was being constructed and as it emerged through the interaction with the tutor, course participants, materials, and the participants’ personal experiences and values.

FINDINGS
In order to show the complexity of the meaning making process, the data will be presented in two different sections. First, an overall map of the participants’ cognition with reference to specific people, events, institutions and places will be offered to illustrate how the network structure of complex dynamic systems can be identified in their reflections. Second, the reflections from one day of the training will be presented and thematically analysed, using journal entries and anonymous questions. It is hoped that this will present how different thinking processes are triggered as a response to the same stimuli and input, and how premeditated learning outcomes may be completely unrealistic in the light of the unpredictable nature of complex systems, such as teacher learning.

Creating a Cognitive Map of Learning
The thematic coding of the data revealed that participant reflections were focused on four major concepts that reached from the past, across the present, and into the future: self as a learner, self as a teacher, self as an administrator, and personal self. Of course, it was not always possible to achieve an exact classification of the events they recorded in their journals as considerable overlaps existed between these categories. For example, one entry in Flora’s journal allows multiple coding:
I smiled when [the tutor] said: Teaching is like being a fish in a fishbowl. People scrutinise you. Well, I do not have a problem with that; I am a very vain fish, I love being watched. Haha. I think my problem is when my students start not to look at me. (Flora, Reflective Journal, Day 1).

This entry lends itself to different coding. First, it can be coded under self as a learner, since there is a reference to the context of the course and the thinking process which was initiated by a comment/point of the course tutor. Secondly, it can also be classified as a reference to self as a teacher, since Flora is talking about her own students, thus assuming the role of the teacher. Finally, it is also possible to code this reference under the personal self, since there is an explicit mention of a personality trait, being ‘vain’, which is not directly linked to her professional capacity of an educator. As a result, when such overlaps occurred, the episode was coded under each possible concept.

The episodes were then filtered to contain only references where concrete people, places or institutions were mentioned, i.e. where participants made an attempt to link new information or understanding to a specific episode in their lives as opposed to abstract, theoretical considerations of the meaning they were creating. One such reference point was the self, as was exemplified in the above episode in Flora’s journal. However, there were many more as the following quotes demonstrate without any attempt to being exhaustive:

- **Family:** “My parents grew up at the time when foreign-run convent schools were all over Manila and European nuns and Irish priests spoke English to all the students” (Eszter, Reflective Journal, Day 4).

- **Fellow learners on a specific course:** “The situation made my classmates and I suffer, and this suffering, I think, had a huge impact on us” (Anna, Reflective Journal, Day 2).

- **An educational institution:** “For one, as an administrator, I have the privilege to make my voice be heard within the academic community of [name of institution]” (Bob, Reflective Journal, Day 10).

- **Students:** “The best teacher qualities activity reminded me how I deal with my students. Do I encourage them? Do I affirm them? Do I take time to look into their personal growth? Do I inspire them?” (Flora, Reflective Journal, Day 1).

The references reached over a wide scope of situations and included past, present, and even future encounters with people, ideas and events. Therefore it seemed important to place these on a timeline to indicate how the meaning and understanding generated during the course make the participants’ thoughts jump back and forth between the past and the future, rather than following a neat, easily predictable train of thought. Having
done a frequency count of the four main concepts, they were visually represented in Figure 1.

The different circle sizes in the figure are proportional to the frequency of the concepts’ occurrence in the reflective journals and depict how the participants were thinking of the topics discussed on the course.

It is clear that some interesting insights can be deducted from the figure. First of all, there seems to be a difference between male and female participants’ references. It seems that while female participants (Eszter, Flora, and Anna) used more specific references in their reflections, their male peers (Jamie and Bob) kept their reflections at a more abstract level, that is, their discussion tended to generalise rather than specify and anchor significant meanings in terms of past, present, or future times. This means that although the ‘lack’ of specific references does not equal with an absence of reflection, its nature, the meaning making mechanisms of abstract vs. specific thinking – has an impact on its volume. This is also testified by the number of words used for the reflections (Table 1).

Table 1. Word count of reflective journals

<table>
<thead>
<tr>
<th></th>
<th>Jamie</th>
<th>Eszter</th>
<th>Flora</th>
<th>Anna</th>
<th>Bob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Words</td>
<td>2,605</td>
<td>5,473</td>
<td>6,205</td>
<td>2,887</td>
<td>4,138</td>
</tr>
</tbody>
</table>

Figure 1. A cognitive map of major concepts in participants’ reflective journals
When the major concepts of self are examined it is noteworthy that the present is dominated by the concept of self as a learner. This is, of course, not surprising as the participants were on a course where their dominant role was that of a learner. Hence, most references linked to the present were made in connection to the course tutor, what he said, how he presented issues or answered questions, and to the other course participants. One extract from Flora’s reflective journal illustrates this:

*I presented my plan for Literature Circles and I smiled when Jamie told me that [the course tutor] said the “simulation” part of my poster is brilliant. I am an adult but I still feel elated when my teacher mentions a sentence of affirmation* (Flora, Reflective Journal, Day 6).

The extract demonstrates how Flora is positioning herself as a learner on the course, making reference to: (a) an assignment (poster presentation); (b) discussion with another participant (Jamie’s comment) which points to camaraderie; and (c) the course tutor who is portrayed as one who is to judge student performance.

It is important to point out, however, that being a learner is in many cases linked to being a teacher learner, that is, being a professional for whom continuous development is an essential part of the self. This is not an easy concept to accept within a traditional educational setting where the teacher is assigned the role of ‘knower’ rather than someone who needs to learn or further develop. This is shown in Bob’s journal when he says:

*I am still somehow grappling with this experience of a paradigm shift from looking at myself as a teacher, and a teacher learner. There is really a big difference between being a teacher where you deal with students in a typical classroom setting sharing your knowledge with your students.* (Bob, Reflective Journal, Day 2).

The self as a learner concept dominates the present time. When it comes to references made to future events or roles, it is interesting to see that none of the participants were seeing themselves as ‘learners’. They were mainly concentrating on their roles as teachers, often in relation to what they were going to do with their students in the coming semesters:

*The challenge for me as a teacher is on how to incorporate these useful skills in the lesson, not just as part of incidental learning. Hmmm. That’s something I must think of.* (Jamie, Reflective Journal, Day 1).

*To prepare my students for actual teaching scenarios like these, I will have to tap on their knowledge, train them to execute this knowledge and let them continuously reflect on their relationship with their students and with their colleagues. When it comes to assessing their performance or any other colleague’s performance, I will make sure that I put in great consideration the*
Another concept linked to the future is the self as administrator. This seems to indicate that the post-graduate course is opening new opportunities for the participants and they are to assume more leadership roles in their respective contexts as a result of their higher qualifications.

When I act as a supervisor, I will make sure that I will not miss pointing out what teachers did well first before I start calling their attention to their weaknesses ... starting this year, I plan to assign a mentor to the newbies in our department. (Flora, Reflective Journal, Day 6).

When I come back to my own school, I will submit my proposal for budgetary allocation to teacher training and seminars and professional development. I know it would not be that easy, but I will design a plan that will convince the president of the school, the vice-presidents to approve my proposal. This will be my target plan for this coming Academic Year. (Bob, Reflective Journal, Day 9).

Similar to how the future tends to be exclusively dominated by teaching and leadership references, the past is dedicated to the self as learner. This is not unexpected, as most references here are linked to previous incidents as learners in grade school or at different higher education courses. Mention is also made of in-service teacher training courses, allowing the teacher role element to surface, together with anecdotes of the self as a novice teacher. What is striking in Figure 1 is the ‘absence’ of the past in Bob’s journal. However, when the journal is analysed it becomes obvious that he probably had a difficult time as a young learner and an attempt to suppress such memories is understandable:

The topic has gotten so personal to me this day. I could feel the difficulties pupils in the public school system have to go through in getting an education. Looking back, I was one of them. I could still vividly remember the 5 km long walk from my home to the school during my elementary years, and going to school with an empty stomach, just a heart full of idealism that one day, I will become successful. (Bob, Reflective Journal, Day 8).

An Intersection of Reflections: One Day on the Course

The temporal diversity and the multitude of references to specific places and people already testify to the complexity of thought processes that shaped the participants’ learning experiences on the course. In this section I will focus on a thematic analysis of one particular day of the course in order to illustrate that although the students were exposed to the same content and participated in the discussions together, their reflections reveal that they made meaning of the sessions in quite different ways, relating ‘new’ information
to an array of concepts and schema, highlighting certain ideas and not mentioning others. First, a brief description of the topic, and the aims and objectives of the two sessions of the second day of the course will be described.

**Day 2: Issues in Defining the Knowledge-base of Language Teacher Education**

The two 90-minute sessions on the second day of the course addressed some general issues in defining what constitutes the knowledge-base of a language teacher education programme. The aim of the sessions was to offer some grounding for the rest of the course in terms of providing a framework for the topics that followed this. It was hoped that by the end of the sessions, participants would have an overview of the trends that shape present day language teacher education and have an understanding of what factors contribute to teachers’ learning both academically and socially.

Three reading texts provided the theoretical input for the sessions:


Freeman and Johnson’s (1998) seminal paper on a proposed model for the knowledge-base of language teacher education, and Tarone and Allwright’s (2005) response to these ideas provided the basis for most of the discussion, while Johnson’s (2009) more recent work offered a general introduction to the trends that characterise the field at present.

A thematic analysis of the participants’ journals indicated four major areas which provided the basis of reflection: (a) being a teacher learner, (b) what makes a good teacher, (c) stages of teacher development, and (d) the complexity of teaching and being a teacher. Within these areas a number of smaller topics surfaced and these will be used to illustrate how individuals attempted to conceptualise the ideas discussed during the sessions (Table 2).

The day’s topic, the knowledge-base of language teacher education and teacher development, allowed for multiple threads in the participants’ reflections; some overlapping, some unique compared to what the others picked up from the sessions. One of the common themes was the concept of the teacher as a learner. In a traditional Filipino society where teachers are usually considered to be ‘knowers’ (e.g. Leon-Carillo, 2007) the concept that a teacher is also a learner may not be an obvious notion to accept. Bob, for example, does not find it easy to cope with this idea and he writes: ”I am still somehow grappling with
this experience of a paradigm shift from looking at myself as a teacher, and a teacher learner” (Bob, Reflective Journal, Day 2). Flora also comments on this shift of roles, though she addresses the issue through one of the regular reflection activities required during the course: the questions/comments participants had to come up with at the end of each day. She says in her journal: “I’m starting to like this activity […] the daily questioning made me more conscious about my thought processes […] I began to have an active ‘relationship’ with the text or with what is being discussed” (Flora, Reflective Journal, Day 2). In a similar vein, Anna also talks about the how the traditional perceptions of teaching – “a knowledgeable person is a good teacher” (Anna, reflective Journal, Day 2) – are already being categorised at a certain stage of professional development (Furlong & Maynard, 1995) for her and leading to many of her peers quitting teaching.

However, it seems that the paradigm shift Bob is talking about has already taken place in some contexts. Jamie comments on the different modes of teacher development discussed in the session (peer coaching, teacher study group, narrative enquiry, lesson study, critical friends group, and peer observation) and says that teachers in the Philippines “are already doing these things though they are called differently” (Jamie, Reflective Journal, Day 2). In a similar vein, Anna also talks about the how the traditional perceptions of teaching – “a knowledgeable person is a good teacher” (Anna, reflective Journal, Day 2) – created a frustrating learning experience for her and leading to many of her peers quitting teaching.

Closely connected to teacher roles, some of the participants reflected on what knowledge, skills and personal traits a good teacher should have (Anna, Reflective Journal, Day 2), and how culture and society actually shape what teachers do in their classrooms (Bob, Reflective Journal, Day 2). Eszter also made an attempt to identify what stage of professional...
development she had made following Furlong and Maynard’s (1995) model and commented on her own career path when saying that sometimes teachers in their professional lives ‘hit a plateau’ and one way of coping with this is to ‘embrace complexity’. She added: “teaching, a profession known for intangible rewards, is a good place to begin appreciating complexity” (Eszter, Reflective Journal, Day 2). This idea was echoed in Bob’s observation who said that “the interplay of many factors such as our society and culture […] affect the education system and the school where learning takes place” (Bob, Reflective Journal, Day 2) indicating that teaching and learning are never straightforward and linear processes and that they involve a great deal of uncertainty and interconnectedness.

The reflection questions that participants came up with at the end of the day are also a testimony of their diverse and unique thinking processes. They indicate that each participant had their own personal learning agenda and interest that acted as a filter to the content discussed in the sessions. It is interesting to note that except for one (question 3), none of the questions have any direct link to the knowledge-base of language teacher education or to teacher development, although they were triggered by explanations, examples, or comments during the sessions.

1. I would like to hear more about Second Language Acquisition as a process. What does this mean for the teacher learning what to teach and how to teach?
2. What should language teacher trainers do in order to help novice teachers overcome the lack of confidence and focus in their lessons?
3. In teacher development, what if some teachers resist to be ’trained’, ’developed’ and ’educated’?
4. Personal question: Did your background on reading books by yourself and not really spending a lot of time for academics influence how you teach Teacher Education? How?

The thematic analysis of one day’s entries reveals interesting points about the reflection of course participants. First, the topics they deal with all start with and relate to the content discussed during the sessions. However, they point further than what was covered in the reading texts and discussions. Second, each participant seems to have identified a unique point from the sessions as the basis for their reflections; they commented on certain topics while they completely disregarded others when they prepared the journals. Third, there is an overall cohesiveness of the reflections that reaches outside of the framework of the course and links the participants together as members of a professional community who share a common cultural (social and professional) background.

DISCUSSION
From the complexity of the data presented above, it seems justified that complexity science is used as the framework for the data analysis. As Davis and Sumara (2005: p. 315) argue
Education and complexity science share one important common theme: They are both focused on the pragmatics of complex transformations. They both ask: How can we induce change when dealing with and embedded in unruly phenomena and systems?

Thus, in the following paragraphs, I will discuss the findings in order to prove that learning within the framework of a SLTE course reflects in its every aspect how complex dynamic systems work. I will use the key features of such systems, such as sensitivity to initial condition, unpredictability, having a nested structure, showing a non-hierarchic network system, and feedback loops, to show how the participants’ learning emerged through interactions with the tutor, fellow course participants, the materials, and most importantly with the self.

Complexity scientists agree that one of the most prominent features of a complex dynamic system is its dependence on initial conditions. Small changes at the outset can lead to great diversions in how the system evolves. As Hagger, Burn, Mutton and Brindley (2007) point out, learners on a teacher education course arrive with different prior knowledge, experiences and values, thus their learning and progress of becoming a teacher is highly unpredictable. In other words, learning that emerges is directly linked to the participants’ background and that being diverse in itself leads to the development of fairly similar, but in fact rather different understanding.

However, it is not only what course participants bring to the course that contributes to how learning takes place. The interactions in the sessions, comments, arguments, and input materials can all trigger different thought processes which in other circumstances may not have taken shape. The mood of the learners, let them be happy or sleepy, and even the physical surroundings can contribute to the development of a certain condition which sparks reflection and learning, as can be seen in Eszter’s Journal who writes: ’As I am working on this journal, I am eating lightly cooked broccoli with Japanese sesame dressing (yum!) and the fractals of the vegetable remind me of what I can still do with this job.’ (Eszter, Reflective Journal, Day 10)

It is also interesting to note that the reflections and thought processes were highly unpredictable in their nature. The topics which were raised in the individual journals traversed through the personal and professional, the factual and the emotional, touching upon and recalling ideas that were unexpected but nonetheless important in the course of reflection. Apart from the numerous recounts of professional learning and teaching experiences of the participants, which were predictable in a reflective journal used in a teacher education setting, participants also shared episodes and thoughts which could not have been forecasted. For example, the dream of creating a scholarship for ‘poor but deserving young pupils’ (Bob, Reflective Journal, Day 8), a self-mocking comment on personality (being ‘vain’) from Flora that she ‘love[s] being watched, haha’ (Flora, Reflective Journal, Day 1), or having a good marriage and a loving husband who supports and
listens to his spouse (Eszter, Reflective Journal, Day 9). These thoughts and comments, seemingly out of context when stumbled upon in a teacher education course, had a very important function: they helped create mental links and internalise the learning experiences and thus promoted the growth of a network of ideas and concepts that create individual meanings for the participants. As Clarke and Collins (2007: p. 161) put it, “complex phenomena represent interactions of events, activities, and practices that coalesce in ways that are unpredictable” but which nevertheless provide meaningful patterns and structure for the individual participants.

Within that complex pattern of ideas it would be foolish and impossible to make any hierarchic order by ranking thoughts at different levels of importance. Thoughts are linked together in an intricate web of interconnected networks, reaching across different fields of science, social and cultural interpretations, and spanning over past, present and future times. The non-linearity of learning is clearly revealed in the reflective journals. A thought captured in the individual journals ‘goes in all directions at once, influencing everything and being influenced in return’ (Crowell and Reid-Marr, 2010: p. 118). In fact, the network structure of learning which emerges from the journals allows the existence of feedback-loops which ‘provide the opportunity for 'learning’ at the local level, that is, new knowledge returning to and being taken up at the point of origin’ (Clarke & Collins, 2007: p. 163).

Finally, mention must be made of the nested structure of complex systems. The data in this study suggest that different systems within systems cohabit the participants’ thoughts, mainly originating from the fact that they are complex individuals. Similar to Roberts’ (1998) idea on how the knowledge base of language teacher education is a system of different knowledge bases, the participants’ reflection indicate that different values, beliefs, roles they played, are playing or will be playing in their personal and professional lives form the basis of how their ideas and learning emerged during the course. These different systems provided the grounds for looking at the ‘known’ from new angles and exploring the ‘unknown’ by creating multiple links between new and old. The small class of five post-graduate students formed an extremely complex learning system, but within this system each individual represented an equally complex system. Thus, examining the whole or looking at the parts would reveal the same level of complexity (Clarke and Collins, 2007; Gleick, 1987; Mallows, 2002) as complex dynamic systems have a fractal-like structure which is scale independent. “Things do not get simpler as you zoom in or zoom out” (Davis and Sumara, 2005: p. 313).

CONCLUSIONS
Teacher cognition is a very complex phenomenon and it is not surprising that although many research projects have tried to analyse the processes of how teachers think, learn, and develop using a multitude of methodologies, there is still space for new interpretations and discoveries in the field. Complexity science as a possible framework for such research has been a neglected option, although it offers a “theory that directly studies systems
that are complex, dynamic, and contextualised (Feryok, 2010: p. 273). This paper thus attempted to fill in this gap in the research literature by analysing teacher learners’ reflections as a complex dynamic system.

The findings of the study clearly indicate that learning in a language teacher education course is not a linear process. It is a complex, dynamic and even chaotic phenomenon. Evidence of the learning that emerged from the participants’ reflective journals indicates that their thinking is non-linear, unpredictable, and highly dependent on initial conditions. This raises an important question: If teacher learning is dynamic and non-linear, why are most teacher education courses linearly structured, following a rigid syllabus and identifying discrete learning objectives for their participants?

Theories of situated cognition (e.g. Chaiklin and Lave, 1996; Lave and Wenger, 1991; Vygotsky, 1978; Wenger, 1998) argue that learning emerges through the participants’ interaction with each other, their tutor, the materials, and the activities in which they are involved while they actively negotiate meaning. This suggests that the ‘knowledge’ generated by different groups of learners is essentially different, though it stems from and shares certain general grounds. The data in this study indicate that participant learning even within one particular community is extremely varied and thus it is impossible to say with any certainty what student teachers will uptake as a result of their education. Therefore, it would be important to seriously reconsider the curriculum and structure of language teacher education programmes.

Of course, problems with the present structure of teacher education have been already identified. Graves (2009: p. 119), for example, argues that the content of the language teacher education curriculum ‘needs to be tailored to learners’ needs’. Although this point is valid, it fails to treat the complexity of the problem. The recognition that learners in different educational or social contexts need different curriculum content does not provide any substantial solution for meeting the needs of different learner groups within the same context or institution. Similarly, Kiss (2011) identifies how a linearly arranged educational experience causes student teachers reject ‘theory’ in the complex, chaotic, and non-linear reality of classroom teaching. He argues that the tension between learning in one system and applying their knowledge in a completely different system prompts many (student) teachers to view their formal teacher education as irrelevant in their everyday practice. Unfortunately, a feasible solution is yet to be offered.

The main reason why institutions are reluctant to make changes in the present linear structure of language teacher education programmes can be connected to recent trends which promote accountability and standards in teacher education. Leung (2009: p. 52) argues, that these trends indicate the “ideological prominence of market forces in public service” which aim to “curb the professional autonomy of teachers and to replace it with a much greater measure of central control” (Broadfoot and Pollard, 2000: p. 13) in order to make sure that an officially endorsed professionalism prevails. It is easy to see that
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policies which have a strong preference for control and quantifiable impact will not tolerate the unpredictability and uniqueness of learning outcomes that would essentially characterise a teacher education course that is modeled on complex dynamic systems.

The solution, however, should not be ignoring the problem and maintaining the status quo. More transdisciplinary research is needed to address the issue and come up with suggestions on how teacher education can maintain high standards and at the same time allow for freedom and flexibility that does not curtail the natural emergence of teacher learning.

REFERENCES


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