Journal of Education, 2016
Issue 66, http://joe.ukzn.ac.za

A systems thinking perspective on change processes in a Teacher Professional Development programme

Bruce Brown

(Received 21 December 2015; accepted 31 August 16)

Abstract

This article discusses the developing practice of Foundation Phase teachers involved in a three-year professional development programme. A number of substantive changes in practice were noted over this period and these changes were supported and maintained by the interaction of a number of different factors. The article takes a systems thinking perspective to formulate and analyse these changes and their interactions, as a complex system of change. This analysis enabled the identification of a number of closed loop interaction effects that supported and maintained the changes in practice. As well as providing insight into the particular change processes in this professional development programme, the article demonstrates the efficacy of this analytical perspective both for the analysis of the complex systems of change arising in professional development, and for the identification of processes and principles relevant to professional development programmes in general.

While remarkable progress has been made in terms of access to education in South Africa, the issue of quality education for all has not been resolved. The majority of learners are under-performing (Department of Basic Education (DBE), 2013a & b; Spaull, 2013, 2015; National Education Evaluation and Development Unit (NEEDU), 2013). The findings of international and national research stress that teacher quality is the most important factor contributing to the quality of learner achievement (Organisation for Economic Cooperation and Development (OECD), 2005; Barbour & Mourshed, 2007; Deacon, 2012; Spaull, 2013, 2015). Of significance to this article is the question asked by Taylor (2014, p. 5): Is the current system of teacher education producing teachers better able to address the issue of quality education? This is an important question given that evidence gathered over two decades shows that in-service professional development has had little impact on quality (p.5).

Tirosh, Tsamir and Levenson (2015) assert that the process of teacher professional development is highly complex: they caution that single causes of change should not be expected. This is similar to the view of Matos, Powell and Sztajn (2009) who contend that changes in practice are influenced by a complex network of interacting factors. These include, inter alia: co-participation in the practice of teaching, developing and expanding teacher communities of practice (Kaur, 2015); a balance of content, community and context (Zehetmeier & Krainer, 2011), and the provision of extensive and ongoing support (Desimone, 2009).

The research on which this article is based, addresses the issue of the impact of teacher professional development on teachers' practices. More specifically, it investigated the developing practices of a number of Foundation Phase teachers enrolled in a three-year professional development programme at a South African university. The first phase of the research followed a grounded theory analysis to identify and describe how teachers' practices changed and what the influencing factors were (Brown, Wilmot and Paton-Ash, 2015). The findings, which are described more fully in the following section, showed that the teachers' practices changed in a number of substantive ways. Furthermore, it was observed that no single factor could be held as the sole or predominant cause of any of the changes that were noted. Rather, it appeared to be the interaction of a number of factors that supported substantive change in the teachers' ongoing, everyday practice. As suggested by Tirosh *et al*. (2015, p.158), such "co-dependency" within a "dynamic environment" may even sustain the impact of the programme over a more extended time frame.

This article demonstrates how a shift in the focus of analysis, from influencing factors, to the interactions between these factors, may provide valuable insight into the dynamics of the professional development environment. It describes the second phase of the research, which was oriented within a theoretical perspective that foregrounds interaction – that of systems thinking – and that enables this shift in the focus of analysis. This article provides evidence of how a systems thinking perspective can generate insights for understanding complex change processes in teachers' practices, that are influenced by the professional development programme.

Researching the professional development programme

This research is concerned with changes in practice identified by teachers who took part in a three-year, part time, professional development programme coordinated by the Centre for Social Development (CSD) at Rhodes University and attended by 33 Foundation Phase teachers from two school districts in the Northern Cape. The programme combined a strong academic component (a three-year, accredited BEd upgrade programme) with in-school follow-up and support. Each year, the teachers on the programme attended four block contact sessions of one week at the university, during school holidays, as well as workshops at least once a term, held in their school districts. The teachers were required to complete approximately 10 assignments in the first three quarters of each year. These assignments combined course assessment with consolidation of theories and techniques involving the deliberate interrelating of theory and practice. A field officer was employed on this programme to provide teacher follow-up and support. The field officer lived in the districts and the bulk of her time was spent supporting teachers in their schools. She also attended the block contact sessions with the teachers and facilitated the majority of the district workshops. Programme academic staff visited teachers in their schools once a year and facilitated a district workshop at this time.

At the end of the second year, both teachers and field officer reported a number of changes in the teachers' practice and some changes in assessed learner performance were also noted. To develop insight into these reported changes, a phased research project into the programme was instituted. The initial phase was a case study carried out in the third year of the programme, focusing of the practice of the teachers. The aim was to identify and describe changes in practice reported by teachers (the students) participating in the programme, as well as particular practices in the programme that may have contributed to these changes. Data included a questionnaire completed by all teachers, observations and semi-structured interviews of the academic staff and the field officer, as well as of the principals and programme teachers from a sample of 11 schools that had teachers enrolled in the programme. Teacher and principal interviews were carried our during school visits, when the researcher also observed at least one lesson by a teacher on the programme and recorded observation notes on the school and lesson observed. Three other teachers and one parent were also interviewed.

A grounded theory methodology was followed for the collection and analysis of the data. The methodology and results of the initial analysis have been reported in Brown *et al*. (2015). A number of substantive changes in practice reported by teachers and principals (or colleagues) and supported by the researcher's observations (and in some cases by assessment results) were identified in this phase of the research. Broad themes that emerged from the grounded theory analysis included: changes in teachers' goals, motives and evaluation; a move from presentation to participation in the classroom; projecting understanding and insight onto the world of practice; and improving resources and the classroom setting. In addition, themes that related the programme to constraints and support for changing practice were identified. These were: dealing with an extensive workload; the interplay between theory and practice in the programme, and the influence of the field officer. Although teachers were generally confident that they would maintain the reported changes in their practice, the time frame of the research project was such that this assertion could not be tested by the research – a follow up project will be necessary to investigate this issue.

The third phase of this research, involving a systems analysis of these changes, based on the same research data, is reported in this paper.

A systems thinking perspective of change

Systems thinking, is a way of viewing phenomena as systems of interacting elements. It involves balancing the analysis of local, small scale details of system elements, with the analysis of global, large scale properties of the system as a whole. This approach facilitates the analysis of interactions within the system and the possible manner in which these interactions may affect the functioning of the system as a whole (Steeg, 2000; Lemke & Sabelli, 2008). According to Jacobson and Wilensky (2006) a complex systems perspective can contribute to the learning sciences on both the conceptual and the methodological levels. While computational methodologies provide predictive power, analytical and descriptive methods such as network analysis allow the development of conceptual insight into complex educational systems. Systems are often specified as networks of interacting elements. Here both the elements (particular, small scale phenomena that may be reliably identified and described within the system) and the interactions between the elements (the manner in which each element influences another)

are seen as important. A network analysis of a phenomenon involves the identification and characterisation of elements and interactions, resulting in the description of the system as a network of elements connected by their interactions.

The network analysis generates an augmented directed graph (consisting of a collection of nodes, where some nodes are joined by links that are directed from one to the other, and a label that augments the link with some information). This graph may be represented visually in a qualitative system diagram (Steeg, 2000). A simple, generalised example of such a diagram is shown in Figure 1. Figure 1 illustrates a network in which identifiable elements are displayed as rectangular nodes, and the direct influence of one element on another is displayed as two arrows with an intervening label, from one node to another. As it relates to our analysis, the nodes are elements of change and the links represent interactions in which one change element serves either to support (maintain) or to conflict with (undermine) the other. As an example of the propagation of influence in Figure 1, note first that element A directly influences element B. But any resulting change in element B, would also change the direct influence of B on element C. In this way, element A would indirectly influence element C.

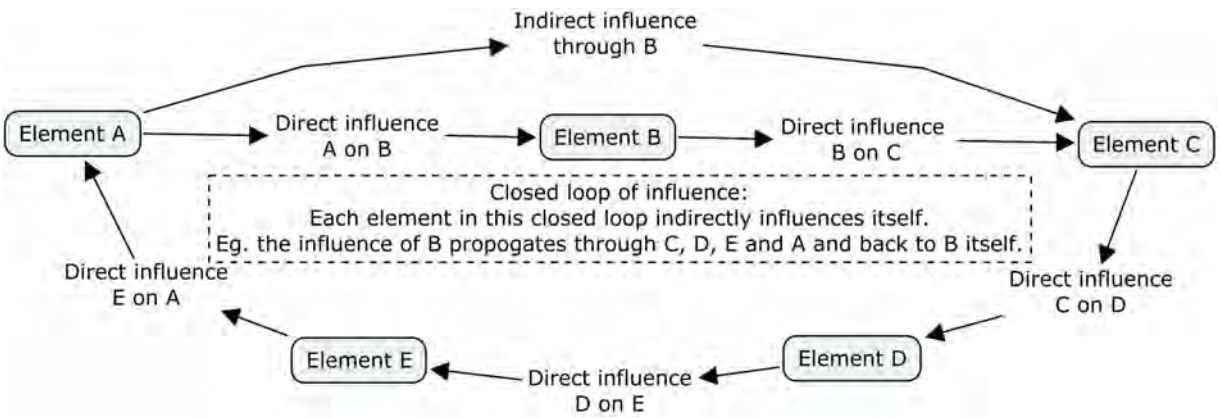

Figure 1: Simplified system diagram illustrating nodes, links and loops.

A chain of influence which closes on itself to form a loop may be termed a **loop of influence**, or a **feedback loop.** In such a loop, the influence of each element is propagated through the loop and so returns to influence the element itself. Such loops require a fundamental conceptual shift in causal analysis, that is evident in systems thinking – a shift from **linear** to **circular causation**, where any element may indirectly influence itself, because its

influence is propagated throughout the system through the interactions between the elements. This has two important implications: First, there is no original cause that initiates and maintains any effect spread though such a loop. That is, the question of original cause is no longer appropriate in this case. Second, that a more appropriate question for such a loop of influence is whether any particular response pattern of the system is stable (maintained by the loop) or unstable (undermined by the loop).

The move from local to global in systems analysis, is made by investigating the way that the system interactions aggregate, preserve and dissipate properties of elements. Based on this, one investigates the manner in which particular response patterns of interacting elements may be changed, or maintained by their interactions within the system. One also investigates the possibility that response patterns may give rise to observable aggregate properties of the system as a whole. Of particular relevance for such an analysis are the concepts of 'emergence', 'self organisation from decentralised interactions' and 'positive feedback loops'. Emergence relates to stable response patterns that may generate observable aggregate properties and is described by Jacobson and Wilensky (p. 6, 2006) as "how local interactions of elements in a complex system at a microlevel can contribute to higher order macrolevel patterns". Self organisation from decentralised interactions relates to the observation that consistency in arrangements does not occur as a result of a centralised controlling element with the goal of maintaining that arrangement. Rather, such a stable pattern is a consequence of the interrelationships of the elements in the system – it is a bottom-up, emergent phenomenon (Mason, 2008) and not a top-down goal directed structuring of the system.

Positive feedback loops can be seen as one mechanism of self structuring. As loops, they are closed loops of interactions. Feedback relates to the influence of a property of an element, when it is 'fed back' to that element after being transmitted through the loop. Positive feedback occurs when changing a property results in an influence that maintains that change after being fed back through the loop. A positive feedback loop will then have the global effect of maintaining, or even amplifying the change of that property, as the system evolves. Again, it must be emphasised that this occurs without any centralised, directing control, but rather as a consequence of the local interactions of the system. The result of a change in a property of a system with positive feedback, is generally a change in the global state of the system.

The change will continue until it is counteracted by other influences in the system that were less important in the initial state of the system but become more pronounced as the property increases. In the system considered in this paper, the influences of time and workload had such a stabilising effect on system change.

This research used the method of network analysis, together with these concepts of systems theory to construct conceptual models of the system of changes identified in the programme. The starting point for this analysis was the collection of elements of change in practice that had been identified as emergent themes in the grounded theory investigation of the first phase of the research. A network analysis was then performed to organise these themes and their possible interactions. It is important to note that these elements of change and their possible interactions were identified as emergent themes in phase 1 of the research analysis data and were not imposed through the systems analysis. In the network analysis, the researcher organised these themes as change elements and their interactions. Detailed qualitative system diagrams of the system of interacting elements of change identified through this analysis, were then drawn to depict this system. This was done using the 'CmapTools' concept mapping software (Cañas, Hill, Carff, Suri, Lott, Eskridge, ... & Carvajal, 2004).

Once the detailed systems had been constructed, they were searched to identify and analyse circular causation (positive feedback loops) within this model of the system of practice. It is the argument of this paper that these positive feedback loops may be influential in changing the global state of the system, that is, in leading to substantive changes in the teachers' practice. As emphasised by Mason (2008), any global change in a complex system occurs through the interaction of small changes in many factors and it is necessary to attain a critical mass of such changes distributed throughout the system in order to achieve and maintain the global change. Lemke and Sabelli (2008) identify a number of elements important for the modelling of the dynamics of qualitative change in complex social systems. In the case of the system of practice of the teachers involved in the programme, these include changes in: daily routines; teaching environments; and the understanding and disposition of the teachers. The analysis produces a qualitative local model of the particular changes in the system which should be seen as unique in its individuality as well as, "as an instance of more general processes" (p.121).

Methodology of the second phase of the research

The first phase of research identified and described changes in practice reported by teachers (the students) participating in the programme, as well as particular practices in the programme that may have contributed to these changes. Each of these broad themes encapsulated a number of specific changes in the teachers' practice. Viewed individually, each specific change had some influence on the global practice of the teachers. But no one change emerged as causing and maintaining the others. Rather, each change supported others, which then supported it in turn. It is these combined interaction effects that appeared to maintain cumulative changes in the global practice of the teachers. The second phase of analysis sought to identify and describe these interacting systems of change and the manner in which they contributed to the overall change in teachers' practice, as well as the possible influence of the professional development programme to support and maintain these changes. The result was a conceptual model of the systems of change, presented graphically as a systems diagram.

A process of network analysis was followed in the second phase, to generate the conceptual model. Based on the changes identified in the first phase, an augmented digraph was constructed to formalise the network structure of the system. System diagrams (Steeg, 2000) for selected subgraphs of this system are provided in Figures 2 to 5. The process of network analysis will be presented using examples drawn from these diagrams.

As discussed by Butts (2009), a fundamental step in this network analysis was the identification of phenomena in the system that could be bounded and described as distinguishable elements – the nodes of the system graph. The scale and the framing of the analysis was important to identify structural system elements and interactions appropriate to the particular research questions being asked about the system. In this study, the criterion used to identify a node was that it should be an element of practice in the school or programme, in which change was noted at some point in the project data, or which had been identified as contributing to change in some way. That is, nodes were identified elements of programme, or practice, that were change related. A formalised description of each element was constructed, that distinguished and identified that element. These descriptions were included as augmenting information for the nodes of the system graph.

Nodes are represented as rounded rectangles in the system diagrams, with a brief formalising description of the element, inscribed within the rectangle. Figure 2 includes nodes such as: ‘Changing/maintaining the classroom setting’ and ‘Children’s enjoyment of the process’. To improve the readability of the diagrams, some nodes describing similar changes and having similar interaction effects were combined, for example, the combined node in the middle left of Figure 2, representing two goals that many teachers developed throughout the programme: ‘1. Caring for the health of the child.’ and ‘2. Creating a pleasant and respectful environment for children.’ To further improve readability, some nodes displaying functional similarities were displayed as grouped within larger rectangles. Although suggestive of certain functional categories in the analysis, these grouping rectangles were included in this paper purely to simplify the readability of the diagrams.

Once the nodes were identified, interactions between pairs of nodes were then formalised as links in the system graph. In order to facilitate linking, the change related to each element was formulated as the increase or decrease of some property identified in that element of practice. System links were then identified as interactions in which changes in one element would contribute to corresponding changes in the other. Links were directed from the element providing the influence to the element being influenced, resulting in a directed graph. Reciprocal influences were included as two links. As with the nodes, formalised descriptions were included as augmentation to the links. Links are indicated on the system diagrams, by two arrows indicating a path from one element to the other, with the augmenting description of the link shown (with no outlining rectangle) between the two arrows on this path. Referring to the earlier example in Figure 2, the teachers’ developing goals relating to children’s health and a pleasant and respectful environment, provided an orienting purpose for teacher’s work to change and maintain the classroom setting in goal appropriate ways. This is indicated in the link from the right edge of the ‘Teacher goal’ rectangle, through the description of the link ‘orienting purpose for’ to the element for ‘Changing/maintaining the classroom setting’.

Note that change (in terms of increase or decrease in some identifiable property) is fundamental to the identification of both nodes and links in this system graph. For this reason, this conceptual system model will be termed a change system. The definition and construction of such a change system for teacher professional development is a methodological innovation of this research. It should also be noted that the changes and influences are

identifiable but they are also complex processes and for this reason are not readily quantifiable. The network analysis thus provided a qualitative understanding of this change system and not a quantitative, numerical model of the system process as is the case for block or flow diagrams commonly used in systems analysis (Steeg, 2000).

Having constructed the change system formalised in the system graph, the graph was analysed to identify positive feedback loops, here termed positive loops of influence. For such a change system, the fundamental systems concepts of positive feedback loops, self organisation and emergence (Jacobson and Wilensky, 2006) are closely related. A positive feedback loop implies that positive change in any element supports positive changes in succeeding elements of the loop and this influence returns to support itself. In this way the local interactions align and support positive and stable changes in all the elements of the loop – a self organisation of change through a loop of local interactions. These aligned local changes may then be identified as a global change in practice that emerges through the self organising effects of the supporting local interactions.

Due to the complexity of the system, it was found that many supporting loops were richly connected to form supporting subsystems. These subsystems were identified as appropriate global units of analysis. An emergent, global change of practice was then sought to conceptualise and describe the self-organised changes in each supporting subsystem. Five global changes emerged in this way from the analysis. They included changes in: the teaching and learning of literacy; the teaching and learning of mathematics; the teaching and learning of life skills; caring for the health of the child; and the classroom as a pleasant place to be. These changes will be discussed in more detail in the following section. Each emergent global change incorporated self-organising changes in many local properties that combined to maintain the emergent change. Following the links in the diagram provided insight into how the influence of each element propagated throughout the subsystem. Supporting links in the system diagram indicated mechanisms through which each change in the subsystem served to support and maintain the rest and thus maintained this as a stable configuration of changes in practice.

The professional development programme was an external and time limited addition to the system. To complete the analysis, possible direct effects of the professional development programme on the teachers' practice were also included in the identified change system. The time limited nature of the

programme implied that stable changes in teachers practice would require supporting loops of influence formed only of elements of the teachers' practice. As a result, the direct influence of these programme elements could only be transient. That is, programme elements may initiate change and help to overcome the initial resistance of the system to change, but stable change requires the effects of changes in practice to independently maintain these changes.

Analysis and discussion of systemic effects

Five subsystems supporting changes in practice were identified in the analysis, three relating to the academic teaching practice of literacy, numeracy and life skills in the classrooms. Due to the similarity of these subsystems and the fact that the programme engaged most extensively with literacy teaching, only the literacy subsystem is discussed in detail in this article. The other two subsystems identified do not relate directly to the academic programme in foundation phase teaching. But they appeared to have an important impact on teachers' practice and on both teachers' and learners' experience of this practice. The emergent changes in practice identified for these subsystems were: caring for the health of the child in the class; and setting up and maintaining the classroom as a pleasant place in which to be. The following sub-sections present a qualitative system diagram describing each of these three sub-systems and then discuss, the loops of influence that may be identified in the diagram and that may serve to support and maintain the change in global practice.

From the network analysis, the influence of the professional development programme in each of these subsystems showed a number of similarities. In each case, it was extensively linked to feedback paths that involved the extended experience of the teachers. Because of this similar structure, this aspect of the sub-systems has been presented and discussed in a separate sub-section below. This also allows a simplification of the diagram of each sub-system, through the representation of this input and feedback path as a single element (the 'programme/experience feedback path'). This does require some flexibility in the interpretation of the links from this path, to ensure appropriate alignment with each corresponding target element.

Caring for the health of the child

This subsystem of change is shown schematically in Figure 2. It involved a number of substantial and clearly noticeable changes in the classroom setting, resources and processes. The primary motivating purpose of the teachers was to improve the hygiene of classroom practices. But they also worked to make these changes in a manner that created a pleasant and respectful environment for children, showing this as a secondary motivating purpose in this work.

One supporting loop in this subsystem can be seen on the left side of the diagram. Tracing the interaction from the middle left (bold) rectangle, the teachers' goals to care for the health of the child and create a pleasant and respectful environment, was the orienting purpose for changes they made in the classroom setting and resources, to set up infrastructure and classroom processes for dispensing clean water for drinking, for eating the school meal, and for washing hands and using the dirty water for the gardens. In addition, the teachers worked to facilitate the children's engagement in, and ultimately self-regulation of, these processes. The contribution of these processes to improving hygiene in the class, was noticed by teachers and by other school staff, resulting in a positive evaluation of their practice in relation to their orienting goal, which then informed and further supported this choice of goal (closing the loop through the bold arrow to the goal element). In addition, the teachers had worked to ensure that the improvements in infrastructure were organised and attractive additions to the classroom. Also treating the meal as a social occasion also carried an acknowledgement of the child as a valued member of the society and so increased the respect for the child in the class. This supported the second goal of achieving a pleasant and respectful classroom environment for the child.

Children's experience of these processes also formed closed loops of interaction that supported their maintenance. These are evident in the bottom right side of Figure 2. First, the children's enjoyment of these processes encouraged their continued participation. Secondly, in keeping with the teaching goals of the teachers (middle right element) the teachers informed the children and facilitated discussions about why these processes had been instituted, during the children's performance of these processes. This contributed to the children's developing understanding of germs, health and hygiene and thus satisfied and further strengthened the teaching goals of the teacher (closing the loop to the middle right hand goal element). An additional feature of these processes for washing and drinking is that children

quickly developed the skill to be able to do this when they needed to and in this way their capacity for self-regulation was increased – contributing positively to this developing goal of the teachers. The resulting deepening understanding and skill of the children in maintaining these processes also contributed to a deepening engagement in and commitment of the children to the performance of these processes, thus creating an additional two closed loops in the bottom right sector.

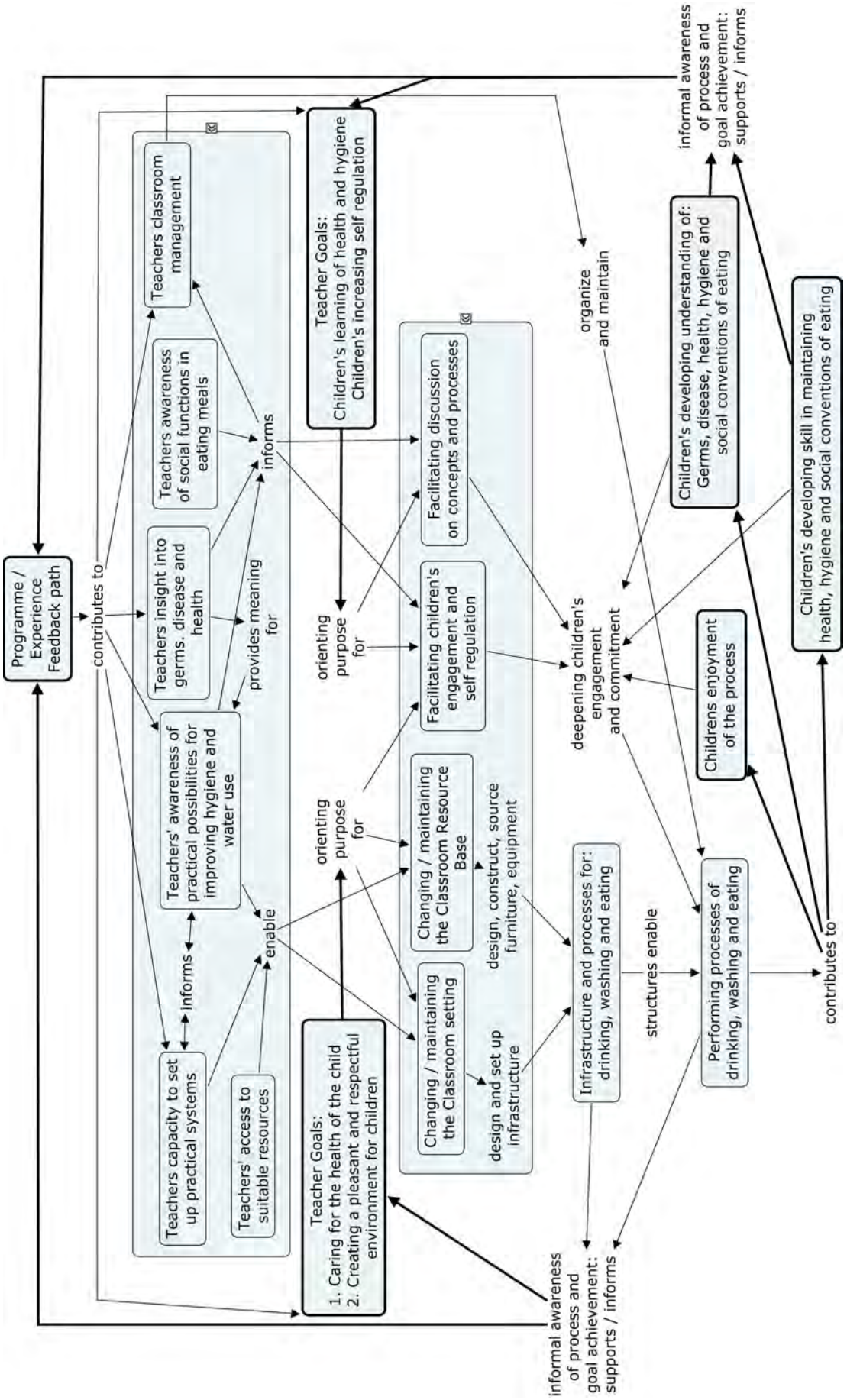

Figure 2: System of changes relating to caring for the health of the child

Finally, the layer of elements illustrated in Figure 2 above the teachers' goals, identify a number of factors that contributed to teachers' instituting these health systems in their classes. It should be noted that the only feedback path that closes the loop with the elements of this section (and so supports the maintenance of these elements) is that due to extended experience. A fundamental element appeared to be the teachers' realisation that they had the capacity to institute such systems in ways that were both practical and effective. This, together with the importance of practically caring for the health of the children in their class, were two important insights that received particular stress from the programme's field worker. Her encouragement and practical insights contributed greatly to the teachers' motivation and their initial efforts to introduce these systems. The programme also contributed to developing a deepening awareness of germs, health and hygiene and increasing skill with developing resources, setting up functional classroom systems and facilitating these processes. But not all the impetus derived from the programme – a number of efforts seemed mainly due to the initiative of the teachers, supported by the field worker. Examples of these were the incorporation of social aspects of eating into the school meal, the use of waste water to develop gardens around the classroom, and the improvement of access to and use of the school toilet facilities.

The classroom as a pleasant place to be

Another principle that the programme stressed was that the classroom should become a clean, stimulating and pleasant working environment for children and for the teacher. As well as communicating this principle, teachers were provided with many different practical suggestions and shown examples of how this could be done. In addition, encouragement and practical support for the implementation of changes to the classroom working environment, were provided by the field worker. In this way the programme encouraged teachers to incorporate this principle into their orientation to practice, sought to develop awareness of the possibilities for doing this, and built strategies and skills for implementing these possibilities. Sustained support for the teachers was also provided as they worked to implement these strategies.

The diagram describing this subsystem of change is shown in Figure 3. Note that the influence of programme elements on this subsystem is encapsulated in the programme/experience return path on the right of this diagram. This block contributed to supporting loops for this practice, through the enrichment of

the teachers experience and the contribution of this enriched experience to the maintenance of the developing practice. A more detailed analysis of this return path will be provided in the following subsection.

The system diagram shows a number of layers of changes implemented to improve the classroom experience of the child. The top two groups (three layers) detail changes to the classroom setting and resources. Changes to the setting included augmenting, as well as improving the state of the furniture – and although some furniture had been greatly improved, some remained in a state of disrepair. Classroom furniture had also been rearranged to allow for a number of different activity zones for children to work and relax in. Many different resources for the use of the children had also been created or sourced. Some specific instances of these developments were identified in the data as important and are shown in the second block. These are table settings for meals, subject resource corners, a reading corner and wall displays.

These changes helped form a physical environment that enabled a number of participatory processes, through which the whole child was engaged in the classroom experience. The processes are described in the following layer, and the interaction links show how they draw on the developing setting and the improving resource base of the classroom. A number of different process elements were identified in the analysis and are included in the three composite elements in the system diagram. Each of these processes contributed in some way to a rich classroom experience for the children. Experiential elements that were identified are shown in the next layer. They include the formation of a positive classroom community, a growing engagement in and enjoyment of classroom activities, and two elements relating to children's learning: a more meaningful learning experience and deepening self regulation of their own experience. It did not appear as if any particular process elements had a profound individual effect on the children's classroom experience. Rather, the cumulative effects of the many different processes combined to form a richer and deeper experience.

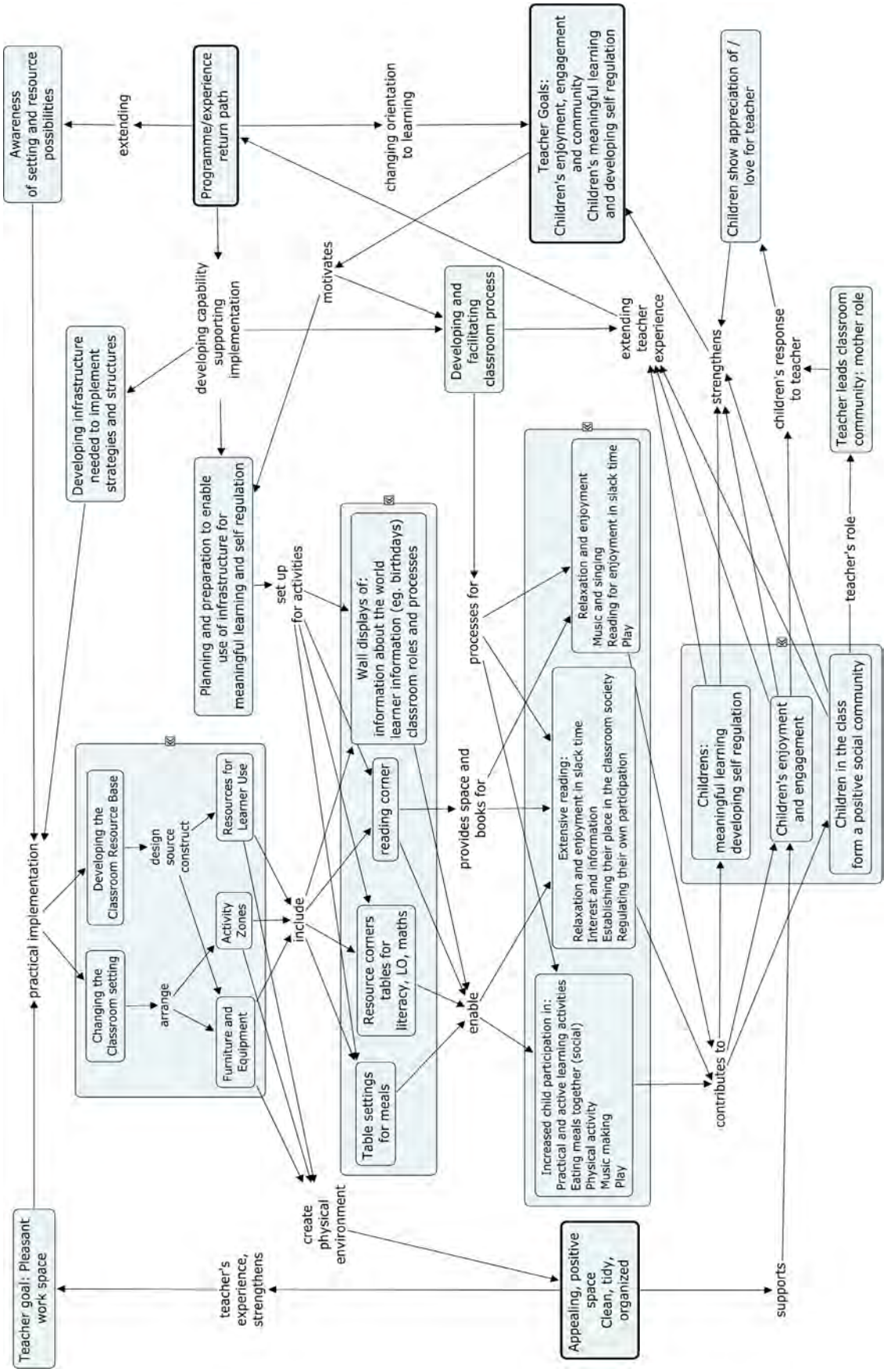

Figure 3: System of changes relating to making the classroom as a pleasant place to be

From the interviews it was clear that the teachers and other staff had informally observed the enriched classroom experience of the learners, which contributed to the children's growing appreciation for and 'love' of their teachers, who became the 'mothers' of these classroom communities. This awareness supported the developing goals of the teachers: to work for children's engagement, enjoyment and community in the classroom and to develop meaningful learning and self-regulation by the children. This positive evaluation strengthened these goals and supported the teachers' continuing efforts to facilitate these participatory processes, to plan and prepare teaching strategies that would generate these processes and to develop their classroom infrastructure in ways that would support and enable this engagement. In this way, three supporting loops were identified, maintaining the changes at different levels of the teachers' practice.

Influence of the programme and the return path due to enriched experience

It emerged from the analysis that much of the direct effect of the programme could be seen as influencing a particular return path in the system – the path of feedback resulting from extended experience. This influence was evident in the five supporting subsystems identified in the analysis. The system diagram describing these interactions is shown in Figure 4 and is discussed in this section.

The return paths through experience are shown in bold in the diagram. The critical node, through which all these paths pass, is the element of extended experience (bottom right) – memories of episodes of practice, from which teachers may draw in the future. This element provides tacit support for the continued development of teaching strategies, of the teacher's orientation to teaching and of the teacher's identity as a teacher. These three elements relate to personal learning from practice and teachers who learn effectively in these ways could be expected to continually build on their experience to develop and improve their practice. In addition to the tacit support for development, teachers' extended experience also formed a basis for explicit and directed reflection on practice, which allowed the explicit development of teaching strategies, orientation to learning and teacher identity.

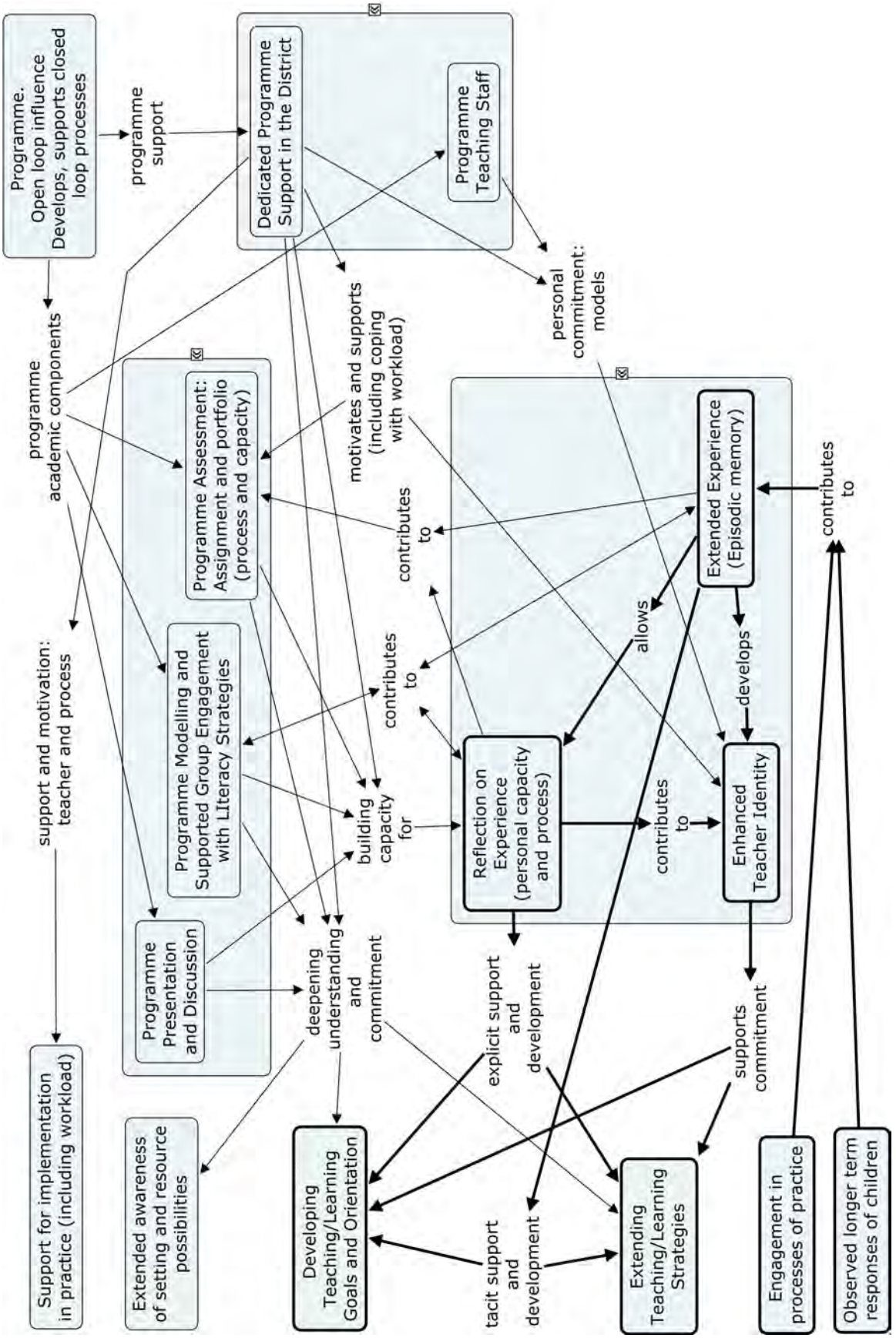

Figure 4: Programme influence and the return path of extended experience

The transient influence of the programme contributed to a number of elements in this return path. An explicit objective of the programme, was to influence teachers' orientation to teaching and strategies of practice. Strengthening the professional identity of the teachers was also a sustained focus of both the academic and the support components of the programme. This stemmed from the strong professional commitment of the programme staff and the acknowledgement that this commitment was an important driver of their practice.

Extensive work had been carried out in the programme, aimed at building the capacity of teachers to reflect on their experience and then develop and improve their practice based on these reflections. This development of reflective and reflexive practice was an important goal of the programme. Programme staff talked extensively about these efforts in their interviews: they agreed that there had been some improvement in this capacity of teachers, but they acknowledged that this development was less successful than they had planned and they were grappling with ways to adapt the programme to further improve this capacity. Written assessments and portfolio reflections were seen as critical for this development and the possibilities for provision of improved support for these processes were being investigated.

Effectively extending the experience of the teachers was also an important aspect of this intervention. A major goal of the field worker was to encourage and support the professional practice of the teachers and in this way to help the successful implementation of classroom practice. Support and encouragement was also provided to help the teachers deal with the extensive amount of work required for the academic programme and for their teaching practice. Programme staff were of the opinion that the experience of coping with a heavy workload may have been important to draw on when teachers needed to deal with the pressure of work in their practice. Further efforts to extend teachers' base of experience were evident in the extensive opportunities for mediated discussion by the teachers, as well as the deliberate modelling of skills and strategies in the teaching of the programme staff. In addition, in response to teacher requests to practice particular strategies, programme staff had decided to include supported group experience with particularly important strategies in the academic component of the course. Through this mediated engagement, teachers were able to add to their base of positive experience of these strategies, in the contact sessions of the course. A number of teachers reported in their reflections that this experience

contributed to their being able to effectively implement the strategies in their classrooms. It is important to note that such practical work complemented a sound and meaningful engagement with theory, aimed at building the teachers' orientation to teaching and learning. Again, a number of teachers noted that their engagement with theory on the course had contributed to their attainment of a meaningful understanding of teaching approaches and strategies that they were implementing. In this way, teachers' experience of meaning in practice was extended through the programme.

Literacy teaching and learning

The complexity of this subsystem was such that a two level analysis was carried out. The first level identified particular details of the practice that were implemented or changed by the teachers. These included the objects and artefacts used in the practice, particular processes that were implemented, as well as elements relating to people, in terms of both individual capacities and social structuring. To allow effective insight into this highly complex system, these particular elements were grouped to form functional categories and an analysis of the change system at this functional level was performed. This second level, functional analysis will be discussed in this section. It is illustrated in Figure 5.

An important motive promoted by the programme involved a change in orientation to teaching, from teacher driven production by the learner, to self regulated engagement with meaning in text, by the learner (top centre). This change in orientation motivated the programme's introduction and development of a detailed and integrated goal set for literacy teaching (below centre).

Two, quite different, supporting loop structures may be identified in this system. In the first, the positive evaluation of the effects of practice against their specific goals for literacy teaching, served to strengthen these goals, as well as the teachers' commitment to maintaining this practice. One evaluation effect experienced by the teachers, was the children's increasing engagement in and enjoyment of literacy oriented activities (above and to the left of the goal element). Seeing the children's increasing engagement in and enjoyment of literacy was a powerful motivator for the teachers to continue to develop and implement goals and strategies that may have led to such engagement and enjoyment. A second evaluation effect involved the results of formal and

informal assessment of the children's developing literacy (left centre). Based on these assessments, the teachers considered the children's literacy to be improving and they also considered the changes in their practice to be contributing to this improvement. As a result, these assessments supported the teachers developing goals and practice.

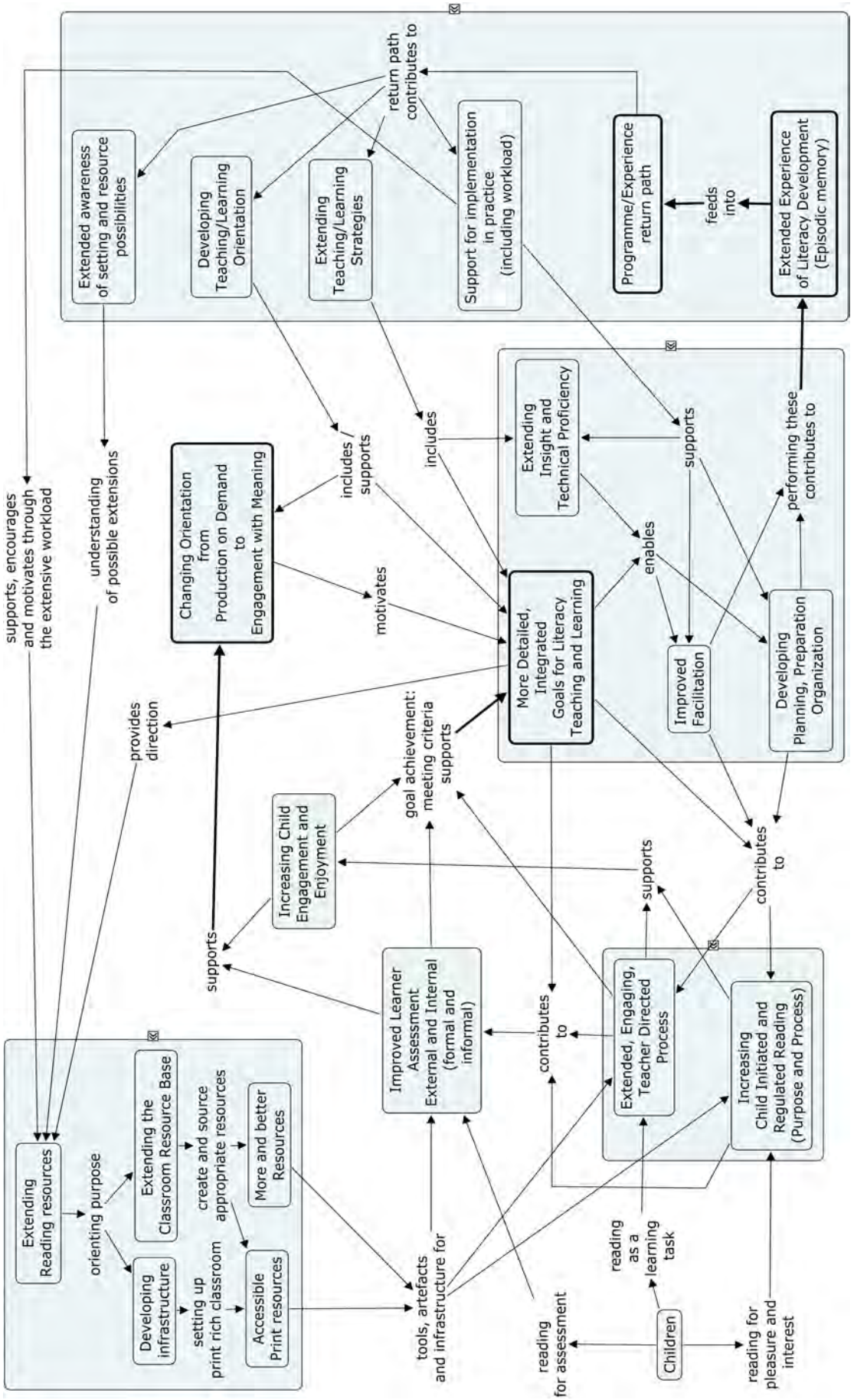

Figure 5: System of changes relating to literacy teaching and learning

The second supporting loop structure involved the return path through extended experience that was discussed in the previous section (and is shown at the right of the diagram). In this case, the experience of extended engagement with literacy development, both in the classroom and in supported group work practice in contact sessions. This extended experience contributed to the teachers developing orientation, goals, strategies in practice and awareness of resource and infrastructure possibilities. As discussed earlier, supporting teachers' developing reflective and reflexive capacities in this area was an important concern of the programme.

The professional development programme contributed to both of these supporting loop structures in a number of specific ways. Developing a teacher orientation to self-regulated and meaningful engagement with text was a fundamental goal of the programme. In consequence, a sizable component of the academic work in the programme involved the development of effective literacy teaching strategies aligned with this orientation. Strategies aimed at extending and improving teacher directed processes in literacy teaching, as well as increasing child initiated and regulated reading, were developed. This was incorporated into the academic programme through the development of appropriate goals, extending insight through deepening theoretical knowledge linked strongly to practice and developing technical proficiency in the teachers' implementation of these strategies.

The academic programme included foci on processes of assessment, planning, preparation, organisation and facilitation. In addition to this, both the academic programme and the school support contributed to teachers' growing awareness of appropriate ways to arrange their classrooms, as well as to create, source and set out resources for effective teaching of literacy. Finally, extensive support for the implementation of strategies in practice was provided, helping teachers cope with the high work load and uncertainty of implementation in the difficult transition period and reach the stage where improvements in children's enjoyment and results would become evident.

Conclusion

The systems thinking perspective used for the second phase of the research, generated a number of insights relating to changes in teachers' practice supported by this professional development programme. These could have

fundamental implications for the design, implementation and research of teacher professional development programmes.

Insight #1: It was evident that no single primary factor could be seen as causing the change in practice. Instead, a number of different factors influenced teacher change. It was the supportive interaction of these many small changes that supported a generally notable change in practice. These changes were also of many different forms, including changes in goals, motivation and identity, changes in the infrastructure and resources and changes in the dynamic classroom process. These different forms allowed the interactions that formed supporting loops.

Insight #2: In many cases, the positive evaluation of practice against a teacher's developing goals formed a return path from operational practice to teachers' goals and intentions. This evaluation served to both strengthen the goals and to support the practices that contributed to the positive evaluation. Through this process, two different types of change were supported. First, it supported the deepening and enriching of the teachers' goals which allowed a more nuanced and informed evaluation of practice and thus allowed teachers to identify previous unnoticed positive effects. Second, it supported the incorporation of adapted processes, resources and resource organisation, which contributed to an improved evaluation of practice. Professional development that influenced these loops would thus require a positive evaluation by teachers of the effects of the development against the goals of their practice. Support for implementation of changes in practice and in particular, support to overcome the difficulties in transition and to carry the additional workload, was thus a critical aspect of the programme.

Insight #3: The second return path evident in this research was through extended experience of effective practice. This provided tacit support for development as teachers' drew on their recollection of experience to adapt and align their ongoing practice. Developing teachers' reflective and reflexive skills enhanced the teachers' capacity to regulate and control this process themselves and in this way to develop improved agency in their own professional development. Developing these capacities was another important focus of this programme and though fruitful, this development was found to be slow and difficult to achieve.

Insight #4: It should be noted from the system diagram that reflective capacity on its own was insufficient for supporting change: it needed the base

of extended experience on which to build. Again this identifies the necessity of the teachers' experience of positively changing practice for effective development.

These conclusions are specific to the particular professional development programme being researched, but they yield generalisable principles and processes that may contribute to the design of programs that contribute to substantive and self-sustaining changes in practice. This demonstrates the efficacy of this analytical perspective both for the analysis of the complex systems of change arising in professional development, and for the identification of processes and principles relevant to professional development programmes in general.

References

Barber, M. & Mourshed, M. (2007). *How the world' best performing school systems come out on top.* McKinsey & Company.

Butts, C.T. (2009). Revisiting the foundations of network analysis. *Science* 325, 414–416, DOI: 10.1126/science.1171022.

Cañas, A.J., Hill, G., Carff, R., Suri, N., Lott, J., Eskridge, T., ... & Carvajal, R. (2004, September). CmapTools: A knowledge modeling and sharing environment. In *Concept maps: Theory, methodology, technology. Proceedings of the first international conference on concept mapping* (Vol.1, pp.125–133).

Deacon, R. (2012). The initial teacher education research project. The initial professional development of teachers: A literature review. Johannesburg: JET Education Services.

Desimone, L.M. (2009). Improving impact studies on teachers' professional development: toward better conceptualisations and measures. *Educational Researcher, 38*(3), 181–199.

Jacobson, M.J. & Wilensky, U. (2006). Complex systems in education: Scientific and educational importance and implications for the learning sciences. *Journal of the Learning Sciences, 15*(1), 11–34, DOI:10.1207/s15327809jls1501_4.

Kaur, B. (2015). What matters? From a small scale to a school wide intervention. *ZDM Mathematics Education (2015) 47*, 105–116.

Lemke, J.L., & Sabelli, N.H. (2008). Complex systems and educational change: Towards a new research agenda. In M. Mason (Ed.) *Complexity theory and the philosophy of education* (pp.112–123). Wiley-Blackwell: Chichester.

Mason, M. (2008). What is complexity theory and what are its implications for educational change? In M. Mason (Ed.) *Complexity theory and the philosophy of education* (pp.32–45). Wiley-Blackwell: Chichester.

Matos, J. F., Powell, A., & Sztajn, P. (2009). Mathematics teachers' professional development: processes of learning in and from practice. In R. Even & D. L. Ball (Eds.), *The professional education and development of teachers of mathematics* (pp.167–183). New York: Springer.

National Education Evaluation and Development Unit (NEEDU). (2013). *National Report 2013*.

Organization for Economic Co-operation and Development (OECD). (2008). *Reviews of National Policies for Education: South Africa.* Retrieved March 11, 2011, from www.oecd.org/publishing.

South Africa. Department of Basic Education. (2013a). *The internal efficiency of the school system.* Pretoria: Department of Basic Education.

South Africa. Department of Basic Education. (2013b). *Education for All. 2013 Country Progress Report: South Africa*. Pretoria: Department of Basic Education.

Spaull, N. (2013). *South Africa's Education Crisis: The quality of education in South Africa, 1994-2011*. Johannesburg: Centre for Development and Enterprise.

Spaull, N. (2015). Accountability and capacity in South African education. *Education as Change, 19*(3), 113–142. DOI: 10.1080/16823206.2015.1056199

Steeg, T. (2000). Systems thinking and practice: a review and analysis of key ideas and their implications for practice in design and technology education. In R. Kimbell (Ed.). *Design and Technology International Millennium Conference.* Wellensbourne: The D&T Association, pp. 203–214.

Taylor, N. (2014). *An examination of aspects initial teacher education curricula at five higher education institutions. Summary Report.* Johannesburg: JET Education Services.

Tirosh, D., Tsamir, P., & Levenson, E. (2015). Fundamental issues concerning the sustainment and scaling up of professional development programs. *ZDM Mathematics Education, 47*, 153–159.

Zehetmeier, S., & Krainer, K. (2011). Ways of promoting the sustainability of mathematics teachers' professional development. *ZDM Mathematics Education, 43*, 875–887.

Bruce Brown
Rhodes University

b.brown@ru.ac.za