Teacher Scripts in Science Teaching

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Abstract:

Awareness of teacher scripts is of crucial importance to reflection on practice, and represents one means of widening the scope of classroom performance. The first part of this work provides a detailed description of three scripts employed by a novice science teacher within the topic of The *Structure of Flowers*, and illustrates the process by which they were derived through a Modelling Instrument. In the second part, the relationships between beliefs and actions are explored through tree diagrams. Finally, there is a discussion of how entrenched scripts may act as obstacles to professional development.

Key words:

Teacher's beliefs and actions, Modelling instrument, Scripts, Science Teaching, Tree diagrams

1. Theoretical framework

To understand teaching is to understand the teacher's thinking and practice (Shulman 1986), and this is fullest when these two domains, thinking and practice, are studied together and examined in relation to each other (Clark & Peterson 1986). Several approaches are available to the researcher in this respect. Modelling teaching (Schoenfeld 1998, AUTHOR 1 2006, AUTHOR et al. 2007 1), for example, focuses on the teacher's cognitions (beliefs, knowledge, goals) and actions. Schoenfeld (1998) believes that if, in a specific context, there is a good comprehension of the beliefs, goals and knowledge underlying a teacher's decisions and actions, then a coherent and detailed explanation of what that teacher did and why can be achieved. He proposes an

instrument composed of three columns, the first specifying information about goals, knowledge and beliefs, along with the triggering and terminating events of each episode, the second providing an overview of the teacher's actions from a general perspective, and the final column giving a very detailed description of each action performed by the teacher.

This paper presents an instance of such modelling through the application of a Modelling Instrument (MI) (AUTHOR 1 2006, AUTHOR 1 et al. 2007, 2008a), derived from adaptations to Schoenfeld (1998a,b, 2000), in addition to studies by Aguirre and Speer (1999), Schoenfeld et al. (2000), Zimmerlin and Nelson (2000), Sherin et al. (2000), Shulman (1986, 1987), AUTHOR 2 (1998), Climent (2002), Cañal (2004) and Santos (1991). The adaptations to Schoenfeld's instrument take two forms. On the one hand, the first column takes into account different dimensions relating to the teacher's knowledge. On the other, the second and third columns are conflated into one, as the focus of the paper is on the identification of meaningful action sequences and the context which produces them, rather than the accumulated minutiae of each brief action. This adaptation will be implemented in section three.

Through the application of the MI, a wide variety of scripts, routines and improvisations employed by a novice teacher was detailed, in respect of the topic *Plant Diversity*, of which three scripts are presented here by way of example, along with one routine and one improvisation, all sharing the theme *The Structure of Flowers*. Of particular interest to this study are the scripts employed by the teacher, through which we aimed to capture the teacher's cognitions beyond his observable performance[1].

[1] This study is not to be understood from a sociological perspective, focusing on the relationships between teacher and students, or on the classroom discourse (Morais et al., 2004). The perspective in this paper is complementary to Morais et al. (2005): whilst these authors deal with the improvement of teacher training

Scripts are theoretical entities, like routines and improvisations, which correspond to an action or to a sequence of actions in a specific context, conceptually dependent on the subject content, such as, in this instance, a science topic (the structure of flowers). People have at their disposal thousands of very personal scripts (Schank & Abelson 1995) which they put to daily use, reducing the demands on their processing capacity in familiar situations (Schank & Abelson 1977)[2].

The Modelling Instrument establishes the triggering and terminating events for each action sequence deployed in class by the teacher. Each action sequence is driven by an objective *in action*, necessarily activated at the point at which it is implemented.

Likewise, the action sequence has its associated beliefs *in action* which condition specific actions or the complete sequence of actions carried out by the teacher. The instrument used for establishing the teacher's beliefs at any particular moment was AUTHOR 1's (2006) procedure for analysing elementary science teachers' beliefs, which draws on Climent (2002) and AUTHOR 2 (1998). The indicators of this instrument are organised into categories (methodology, school science, learning, pupil role, teacher role and evaluation) and locates the beliefs within one of four tendencies: traditional, technological, spontaneous and investigative. It should be noted, however, that in using this instrument the researchers were not interested in allocating the teacher to one or other tendency, and in practice, the indicators were not applied in too rigid a

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in terms of recognition and realisation rules (interaction practices), this paper focuses on the teacher's cognitions.

[2] The theoretical construct *script* arose out of the work of Schank and Abelson (1977) in the field of cognitive and social psychology. A *script* is defined as a structured representation of a routinised sequence of events in a specific context, and has also been employed by and researchers within the field of artificial intelligence.

fashion, not least because no individual can be said to belong unequivocally and uniquely to any specific category (Porlán 1989).

In addition to specifying the beliefs and objective, the action guide also identifies the knowledge brought to bear at the implementation of the action sequence, and this corresponds to the knowledge *in action*. Following Shulman (1986b, 1987), Schoenfeld (1998) and Schoenfeld et al. (2000), the theoretical framework characterises this knowledge into three types (subject knowledge, general pedagogical knowledge and pedagogical content knowledge), with incorporations from Santos (1991) and Cañal (2004). Content Knowledge (CK) concerns the facts, terminology, and key concepts of the subject and specific topics within the subject. It also allows for the fact that the teacher may make errors (Cañal 2004, Santos 1991), for example by repeating the belief of his or her students that plants are nourished by soil and water. Pedagogical Content Knowledge (PCK) refers to the role played by analogy, exemplification, metaphor, illustration, explanation and demonstration (Shulman 1986b, 1987), that is to say, the various strategies available for presenting the contents specific to science. General Pedagogical Knowledge (GPK) concerns the use of Socratic dialogue, interactive dialogue, unplanned dialogue and mini-presentation (Schoenfeld et al. 2000) in dealing with the contents in general.

2. Methodology

This study followed an interpretative paradigm, as endorsed by Latorre et al. (1997), in favour of positivist and socio-critical paradigms, with the aim of emphasising the understanding and interpretation of educational experiences from the perspective of those involved, and of studying their beliefs, intentions, motivations and other features unavailable to observation or experimentation.

Within an interpretative paradigm, it is assumed that the researcher takes a significant role with respect to the interpretation that is carried out (Bogdan & Biklen 1994). In this respect there are two key elements relevant to the research process: *theoretical sensitivity* (Strauss & Corbin 1994), deriving from the researcher's personal and research background, and *phenomenological sensitivity* (Van Maanen 1988 in Geelan 2003), which concerns the researcher's openness to the object of study and others' experience of it.

The design of study also took a naturalist approach (Lincoln & Guba 1985) as the experiences to be studied were not to be divorced from their context but rather studied within their natural environment.

Given that the study was to focus fundamentally on specific issues concerning the cognitions and teaching of an individual, as opposed to generating research findings from which generalisations and broad abstractions could be made (Erickson 1989), it was clear that a case study would be the most appropriate form to adopt, as this would allow the fullest understanding of the case in question (Stake 1998).

Specifically, it was decided that the case study would produce a model of the teaching of a novice teacher, allowing the identification of routines, improvisations and action guides, and hence provide detailed characterisation of his beliefs in action, objectives in action, knowledge in action and his actions themselves, in constant interaction during the teaching of a science topic. In brief, the main objectives of the study were the following: (1) To obtain highly detailed action guides for a novice science teacher; (2) To characterise cognitive elements of the teacher in interaction with his actions; (3) To explore, through tree diagrams, strong relations between beliefs and actions on the part of the teacher's understanding of teaching (based particularly on previously transcribed scripts). These objectives derived from the following research

questions: (i) What is the nature of science teachers' action guides? (ii) What is the nature of cognitions in action, and what part do they play in action guides? (iii) What does the analysis of scripts and tree diagrams bring to our understanding of classroom practice?

The interests of the study went beyond the questions above and were deeply concerned with the area of training and professional development. At the same time, it was not an aim to provide a characterisation of the teacher himself, the subject of the study, but to highlight the action guides employed by him within a science class, the object of the study.

With respect to the instruments for data collection, it was recognised that these would be determined in the course of the study itself according to the developing understanding of the project in conjunction with the literature review, and that in this sense it would follow an emergent design. Lincoln and Guba (1985) note that an emergent design within a naturalist study emerges in cascade rather than being determined beforehand, as it is impossible that the design can be fully known from the outset and can only emerge in relation to the interaction between the subjects and the phenomenon.

The novice teacher in this case study worked in a Primary school in Portugal. At the start of this study he was in his first year as a teacher, and was working on the topic of *Plant Diversity* from the fifth year of Natural Sciences (10-11-year-old pupils), the ninth class of which, covering *The Structure of Flowers*, produced particularly rich data.

Mellado (2003) argues that it is during the first years of one's professional life, when teachers find themselves under numerous tensions, dilemmas and heavy workloads, that their routines and teaching strategies are most likely to be fixed. The aim here was not to arrive at any kind of findings or conclusions that could be applied to

the broad sweep of novice teachers; the choice of this stage of the teaching profession, as suggested above, derived from its importance for establishing routines and teaching practices, amongst which action guides are to be found. Observation and analysis of novice teachers at work can contribute to our inquiry into the professional development processes (which is the aim of the wider research in which this study is immersed), namely by offering insights into how scripts are first formed under the influence of knowledge and habits acquired during initial teacher training (Muñoz-Catalán et al. 2007). The reliance on the textbook by novice teachers due to their lack of resources has likewise been noted (Azcárate & Cuesta 2005); indeed, for this reason one of the guides presented here concerns the use of the textbook.

The research process was initiated with collection of data from the classroom through video recordings of the teacher's lessons. It was decided that this should be the chief source of data because, as Rochelle (2000) notes, more aspects of the interaction are thus preserved, such as the conversation and gestures, and the recording can be viewed an indefinite number of times, thus allowing a finely detailed analysis. This latter was of especial importance in the development of the instrument for modelling teaching, which was to serve as an analytical tool for characterising the details of the phenomenon of teaching. The video was supplemented with audio recordings from a microphone worn by the teacher to ensure that no utterance went unheard.

Data collection was completed with the research notes which recorded information drawn from documents and other items relating to the teacher's practice such as field notes, lesson image, photographs and interviews, both semi-structured and free. Items such as the field notes and photographs of the lessons served to improve the accuracy of the transcriptions. The lesson image is the visualisation by the teacher of how he expects the lesson to unfold (Zimmerlin & Nelson 2000). Nevertheless, these

researchers point out that the lesson image need not correspond directly to the lesson plan as it is formed from the teacher's statements and records of documents which the teacher may use during the class, in other words, an image is put together from various sources beyond the lesson plan. In this study the lesson image helped to characterise the implicit aims of the action sequences implemented by the teacher. Finally, with the exception of a limited number of statements which clarified aspects of the lesson image, no use was made of the interviews in this particular study, although these have contributed to the larger research project of which this forms a part.

The modelling process began with the analysis of the information, which in turn involved the line by line transcription of the audio and video recordings of the twelve classes given by the teacher, who for the sake of anonymity, will be called Rodrigo. Once this had been done, each lesson was divided into episodes and sub-episodes, with special attention given to the ninth lesson (as will be seen in section 3). Each episode represents an action sequence occurring in the class and is underpinned by a coherent set of actions (sub-episodes) on the part of the teacher. The analysis then proceeded to the derivation of the beliefs, objectives and related knowledge for each action or set of actions, to which was added the analysis of the relationships between beliefs and actions observed in the scripts. Given the complexity of these relationships, cognitive maps were selected, following Miles and Huberman (1994), as the best means of representing them (here referred to as tree diagrams).

3. Results and discussion

Rodrigo begins his ninth class with a routine designated *Beginning the Class* ([9.1]). This means that the actions implemented by the teacher have been identified as constituting a set of routines or sub-routines ([9.1.1.], [9.1.2.], [9.1.3] and [9.1.4.])

making up a larger routine. The basic aim of this routine is to get the lesson underway, and was identified as such from repeated observation of the sequence over some three and half months, more than sufficient to establish the episode and recognise it as a routine.

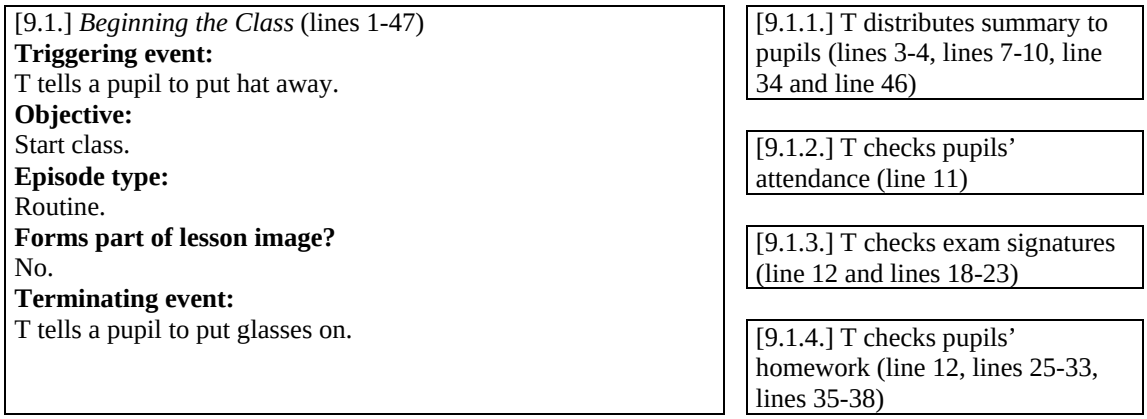

Figure 1. First episode in Rodrigo's ninth lesson, identified as a routine. (T denotes Teacher).

As can be seen in the figure below, the actions implemented by Rodrigo in the course of one and a half hours' teaching, allowed the researchers to identify the following elements:

- two routines (episodes [9.1.] and [9.11.]), concerning the beginning and end of the lesson respectively.
- two improvisations (episodes [9.4.] and [9.8.])
- seven distinct scripts (episodes [9.2.], [9.3.], [9.5.], [9.6.], [9.7.], [9.9.] and [9.10.]).

It is important to emphasise that these theoretical entities were recognised as such by the researchers through close observation of the teacher's lessons and does not necessarily imply that he was consciously aware of them.

[9.1.] *Beginning the Class* (lines 1-47) - **Routine**
[9.2.] *Establishing previous knowledge of content –Structure of Flowers – through a drawing activity* (lines 48-95) - **Script**
[9.3.] *Interactive exposition of content – Structure of flowers –- through reading the book* (lines 96-111) - **Script**
[9.4.] The teacher wants the pupils to bring flowers to the next class, so asks them to do so for homework (112-115) - **Improvisation**
[9.3.] (continuation) (116-136)
[9.5.] *Elaboration of content – Components of the structure of flowers– through book-based activity* (book and diagram distributed by teacher) (137-170) - **Script**
[9.6.] *Interactive exposition of content* – Reproductive system of flowers (171-198) – **Script**
[9.5.] (continuation) (199-290)
[9.7.] *Organisation of content – Components of the structures for support, protection and reproduction of flowers – via a chart* (291-334) - **Script**
[9.8.] The teacher wants the pupils to stick a diagram in their notebooks, so cuts out and gives a figure to each (314-334) - **Improvisation**
[9.7.] (continuation) (335-376)
[9.9.] *Memorisation of content – Components of the structure of flowers – through book-based activity* (377-412) - **Script**
[9.10.] *Content review – Components of the structure of flowers – through reading the book* (413-457) - **Script**
[9.11.] *End of the class* (458-476) - **Routine**

Figure 2. Episodes making up Rodrigo's ninth lesson, and their categorisation into scripts, routines and improvisations.

A detailed example of the process of modelling the teaching is offered below with the aim of explaining how the ninth class was divided into episodes which could be recognised as sets of actions fulfilling the requirements for action sequences set out above (section 2, Methodology), and in turn also recognised as scripts, that is, routinised and standardised actions or sequences of actions, dependent on the science content dealt with by the teacher.

Figure 3 provides the transcript of an excerpt from the same lesson, from lines 48 to 95. Each new line represents single changes in the teacher-pupil(s) interaction. This means that distinct actions cannot be present in the same line, only such actions as have the same meaning but with a different wording.

Line		**Transcription**
48	T:	Who has done it? Close the book. Don't open the book.
49	T:	Listen, in plants, what structures have we already studied? Who
50		knows? What structures have we studied in a plant? Beginning from the bottom
51		and going up, up to now.

S: Root, stalk.
T: The root, stalk, leaf.
T: What are we going to study next?
S: Flower.
T: The flower.
T: You are going to draw in your notebooks what you think a flower is designed, you are going to draw a flower.
T: Think about what a flower is, when we go to the florists, what do they have we are going we are going to buy a rose, a carnation or any flower. What is it like?
T: Imagine it and draw it, that's fine. It's a got a green part and then it's got another bit, not the whole plant, I just want the flower.
T: The teacher shows a plant to the class.
T: For example, is this a plant or a flower? Is all this a plant or a flower?
S: A plant.
T: A plant.
T: What bits has it got? It's got a root, it's got a stalk, it's got the leaves, it's got the flower.
T: What do I want you to imagine? It's just the flower, it's not for drawing the stalk, nor the root, nor the leaves, it's just the flower. Let's get drawing.
T: You, too, Jorge. Come on, Marta.
S: I don't understand.
T: Imagine whatever you want, a rose, a carnation, whatever you want.
S: The pupils draw flowers individually.
T: Close the book.
T: Have you done it yet?
T: I'm not asking for a work of art.
S: I've done it.
T: What is this called? What do you think this part is called?
S: I don't understand.
T: Then write.
T: Come on, Marta, you don't have to draw the plant, just the flower. This bit which you've drawn, what is it?
S: It's the stalk.
S: Sir, what do we have to do when we've finished?
T: Write the names, do the labelling. You all know at least one thing that all flowers have. What's that?
S: Pollen.
T: No, not that.
T: The petals. do you know any other parts which make up the flower, apart from the petals, think. If you know, write it down.
T: Who has done the wrong homework? Who has done the parts of a flower? Tell me.

T: Hey! Hey! Hey! I can see you.
T: The teacher tries to prevent the pupil from opening the book.

Figure 3. Transcript of an excerpt from the ninth class relating to the script *Establishing previous knowledge of topic – structure of flowers – via a drawing activity. (Legend: T denotes Teacher; S a Student).*

Specifically, the excerpt presented in figure 3 relates to the script designated *Establishing previous knowledge of topic – The Structure of Flowers – via a drawing activity*, which consists of two actions: [9.2.1.] [Teacher instructs the students to do a

drawing activity on the topic of study – *The Structure of Flowers*] and [9.2.2.] [Teacher gives students time to draw]. The first action ([9.2.1.]) occurs from line 48 to line 73, and the second ([9.2.2.]) from line 74 to 95.

[9.2.] *Establishing previous knowledge of topic – the structure of flowers – via a drawing activity* (lines 48-95) **Triggering Event:** The teacher tells the students to close their books. **Belief:** (TR39) The initial student diagnostic is based exclusively on the topic content which has supposedly already been taught. **Goal:** Establish students' prior knowledge of topic – Structure of flowers, via a drawing activity. **Knowledge:** Pedagogical Content Knowledge (PCK) – The role of drawing and labelling in establishing prior knowledge of the structure of flowers. General Pedagogical Knowledge (GPK) – The role of interactive elicitation drawing activity in establishing prior knowledge of the topic. **Episode type:** Script. **Part of lesson image:** The topic – flowers – forms part of the lesson image. **Terminating event:** The teacher tries to stop a student opening their book.	[9.2.1.] Teacher instructs the students to do a drawing activity on the topic of study – the structure of flowers(lines 48-73) [9.2.2.] Teacher gives students time to draw (lines 74-95) Interactive dialogue (lines 73-89) Specific content: Structure of flowers

Figure 4. Episode 2 in Rodrigo's ninth lesson, identified as a script. (Legend: (TR39) - Descriptor 39 comprises the category of beliefs relating to evaluation).

As can be seen in figure 4, the script starts with "The teacher tells the students to close their books", which corresponds to the triggering event, and ends when "The teacher tries to stop a student opening their book" (terminating event) before all the class have finished their drawings depicting the parts of a flower. This script also illustrates how the teacher intends to establish the students' existing knowledge of the parts of a flower through the drawing activity, which corresponds to the main goal of the script.

Also identifiable, and intrinsic to the sequence, is the belief underpinning the actions, here that the initial informal diagnostic test of previously taught content is

appropriate to the teacher's intentions. This particular belief falls into the provenance of Descriptor 39 (TR39) in the Modelling Instrument, that is, the category covering beliefs regarding evaluation, and is drawn from AUTHOR 1 (2006) scheme, itself adapted from the work of Climent (2002) and AUTHOR 2 (1998), cited in section 2, methodology.

The third and final component of the script, in addition to its goal and underlying belief, is the teacher's knowledge. In this instance, two areas of knowledge are brought into play: the first relates to the technique of interactive elicitation in reviewing what the pupils had previously studied of the topic (General Pedagogical Knowledge); the second concerns the drawing and labelling activity in discerning their prior knowledge of the structure of flowers (Pedagogical Content Knowledge).

In the next part of the lesson, the teacher implements various action sequences, recognisably scripts, which, human nature being what it is, do not all follow a neat linear progression through to conclusion, but are interrupted and temporarily paused until they are taken up later and completed. Figure 5 below presents an illustration of this disjointed unfolding of a script, in relation to the *Organisation of content – Components of the structures for support, protection and reproduction of flowers – via a chart* ([9.7.]).

[9.7.] *Organisation of content – Components of the structures for support, protection and reproduction of flowers – via a chart* (lines 291-334) **Triggering event:** The teacher writes on the board. **Beliefs:** (TR7) The subject is oriented exclusively towards the acquisition of concepts. (TR/TE15) The student interacts with the material and the teacher, the latter acting as mediator between the material and the student. The interaction teacher - student is not equal, with a stronger flow in the direction teacher-student than vice versa.	[9.7.1.] The teacher draws a chart on the board showing the components of the structure for sustenance, protection and reproduction (lines 291-305) Specific content: Components of the structure for sustenance, protection and reproduction of flowers.

(TE25-28) The teacher organises the subject content to be learnt, which are transmitted via exposition, using organisational and expository strategies aimed at engaging the students. **Goal:** To organise the content – *Components of the structure for sustenance, protection and reproduction of flowers – via a chart* **Knowledge**: General Pedagogical Knowledge (GPK) – The role of the chart, Socratic and interactive dialogue, and mini-presentation in organising the subject content. **Episode type:** Script. **Part of lesson image:** The topic – *The structures for support, protection and reproduction of flowers* – forms part of the lesson image. **Terminating event:** The teacher suspends the action guide.	[9.7.2.] The teacher gives the students time to copy the chart into their notebooks (lines 300-334) Specific content: Structure for sustenance, protection and reproduction of flowers.

Figure 5. Episode 7 in Rodrigo's ninth lesson, identified as a script.

Rodrigo implements two actions: [9.7.1.], 'The teacher draws a chart on the board showing the components of the structure for sustenance, protection and reproduction' and [9.7.2.], 'The teacher gives the students time to copy the chart into their notebooks.' The two actions can be recognised as deploying a script, which is suspended during the carrying out of the second action. At this point, the teacher initiates an improvised sequence, as can be seen in figure 6 below, because he realises that the students need to stick a diagram into their notebooks.

[9.8.] The teacher wants the pupils to stick a diagram in their notebooks, so cuts out and gives a figure to each (314-334) **Triggering event:** The teacher cuts out the diagrams and gives them to the students.. **Goal:** To distribute a diagram to each student, who then sticks it in his/her notebook. **Episode type:** Improvisation. **Part of lesson image?** No. **Terminating event:** The teacher asks who has not yet stuck the diagram into their notebook.

Figure 6. Episode 8 in Rodrigo's ninth lesson, identified as an improvisation.

The improvisation is identified as such against the background of the context of the whole lesson. Nevertheless, the fact that it is here classified as an improvisation does not deny the possibility of it becoming a script in the future. The sensitivity which the researchers have acquired over the course of working on this project allows them to affirm that any improvisation is a potential script; in this instance, however, set against the totality of Rodrigo's classroom actions, the sequence is carried out as an improvisation, without any form of routinisation or standardisation.

Immediately afterwards, as shown in figure 7, Rodrigo returns to the original script ([9.7]) and considers it completed with the implementation of the final action ([9.7.3.] [The teacher talks to the students about the contents of the chart]). He draws an analogy between the components of the reproductive system in plants and human reproduction, and also makes use of Socratic and interactive dialogue with his students.

[9.7.] (continuation of script) (lines 335-376) **Triggering event:** The teacher questions the students on what the set of sepals is called. **Knowledge:** Pedagogical Content Knowledge (PCK) – The role of analogy (between plant and human reproduction) in the organisation of the respective content. **Terminating event:** The teacher makes an analogy between the components of the reproductive system in plants and human reproduction.	[9.7.3.] The teacher talks to the students about the contents of the chart (lines 335-376) Analogy (lines 372-376) Socratic dialogue (lines 351-365) Interactive dialogue (lines 366-371) Mini-presentation (lines 372-376) Specific content: Components of the structure for sustenance, protection and reproduction of flowers.

Figure 7. End of episode 7, representing the final action implemented by Rodrigo.

It should be noted that the actions comprising the script need not necessarily follow a fixed sequence. In this instance they follow the order [9.7.1.] [The teacher draws a chart on the board showing the components of the structure for sustenance, protection and reproduction] ➢ [9.7.2.] [The teacher gives the students time to copy the

chart into their notebooks] ➢ [9.7.3.] [The teacher talks to the students about the contents of the chart], but they could equally be sequenced thus: [The teacher talks to the students about the content of the chart] ➢ [The teacher draws a chart on the board showing the components of the structure for sustenance, protection and reproduction] ➢ [The teacher gives the students time to copy the chart into their notebooks]. This assertion is made possible through long-term analysis of Rodrigo's lessons via observations and video recordings, and reflects the non-linear nature of the classroom reality and the human element of teachers' scripts, which do not require a standardised order to be followed.

It can also be seen that the three actions comprising the script are phenomenologically coherent, that is to say, there is a continuity in the discussion of a specific content or class activity, in this particular case the components of the structures for support, protection and reproduction of a flower, and are directly related to a high degree of activation of an objective, namely that of organising the content into a chart.

Note, too, that the two latter actions in the script do not make reference to the components of the structure for sustenance, protection and reproduction of a flower as the concept of a script treats this as understood; it is sufficient to state only the events strictly necessary for the underlying thread to be followed.

The teacher, then, employs the script as a means of organising subject content. In so doing, he necessarily activates a set of beliefs which conditions the actions to be carried out. One belief which is primarily activated by this action sequence is the fact that the interaction between the teacher and the students is not equal, with a stronger flow in the direction teacher-student than vice versa when the teacher draws a chart on the board to establish that the structure of flowers is for sustenance, protection and reproduction.

Also in evidence is the belief that the subject is exclusively organised towards the acquisition of concepts and/or terminology when the teacher gives the students time to copy the chart into their notebooks. The belief which would seem have most bearing on the action sequence is the fact that the teacher organises these specific subject contents - the structure of sustenance, protection and reproduction – conveying them by means of exposition, but employing organisational and presentational strategies aimed at engaging the students.

In addition to the beliefs that are activated above, it can also be seen that the teacher aims to fulfil his objectives through deployment of his general pedagogical knowledge, in this case that relating to the role of the chart and the use of Socratic and interactive dialogues, and that this knowledge determines how he decides to organise the subject contents in question.

The figure below presents another script, this time concerning Memorisation of content – Components of the structure of flowers – through book-based activity

[9.9.] *Memorisation of content – Components of the structure of flowers – through book-based activity* (lines 377-412) **Triggering event:** The teacher tells the students to write down what a corolla is in their notebooks. **Beliefs:** (TE11) Learning is conceived of as memory-based, with an internal organisation following the logical structure of the subject. (TE14) It is important that students be able to make their understanding of the subject content explicit The articulation of	[9.9.1.] Teacher asks students questions which he formulates from the textbook with respect to the components of the structure of flowers. (lines 377-392) Specific subject contents: Components of the structure of flowers – Carpels and stamen.

what has been learned, in the students' own words, demonstrates the learning outcome. (TR29) The teacher (and/or textbook) provides validation of the information mobilised during the lesson, correcting student errors and supplying the correct information himself. **Goal:** To encourage the students to memorise the subject contents– *Components of the structure of flowers* – through a book-based activity. **Knowledge:** General Pedagogical Knowledge (GPK) – The role of Socratic dialogue and the book in memorising the subject contents. **Episode type:** Script. **Part of lesson image:** The topic – *The structures for support, protection and reproduction of flowers* – forms part of the lesson image. **Terminating event:** The teacher corrects a student in the use off the word "anther".	[9.9.2.] Teacher and students correct the answers (lines 393-412) Socratic dialogue (lines 393-410) Specific subject contents: Components of the structure of flowers – corolla, calyx, sepals, carpels, pistil, stigma and anther.

Figure 8. Episode 9 in Rodrigo's ninth lesson, identified as a script.

The script enacts the teacher's primary objective of getting the students to memorise the key terms for describing the structure of flowers, such as corolla (petals), calyx (sepals), carpels (stigma, style, ovary and ovules), stamen (anther and filament). The beliefs underpinning the teacher's actions are summarised in the descriptors TE11 and TE14 with respect to learning, and TR29 with respect to the primary teacher's role. The first two descriptors concern, on the one hand, the importance of the student's ability to verbally articulate his or her understanding of the material in order to demonstrate a successful learning outcome, and on the other, the internal organisation of the learning, which follows the structural logic of the subject; the third descriptor refers to the role of the teacher (and/or the textbook) in validating the information mobilised during the course of the lesson, correcting mistakes and supplying the correct information.

The script also shows that Rodrigo disposes of the appropriate knowledge regarding the role of the textbook and Socratic dialogue in the memorisation of the components of the structure of flowers, and includes the lesson image, offered by

Rodrigo shortly before the start of the lesson, which confirms that this particular topic was to be the subject and that the students would cover the corresponding section of the textbook to help them memorise the terminology.

Without wishing to offer any further information, but rather shed new light on that already provided from different perspectives, three tree diagrams are presented below which allow strong relationships between beliefs and actions to be detected and explored, albeit at the level of conjecture, with respect to achieving a deeper understanding of Rodrigo's teaching, based particularly on the scripts set out above.

When Rodrigo's scripts are analysed, and specifically those pertaining to *Establishing previous knowledge of topic via a drawing activity*, such as [9.2], there comes to the fore one belief which conditions the two actions implemented by the teacher. This belief corresponds to the fact that initial diagnostic test given to the students is based exclusively on the subject contents that have supposedly been taught previously. Figure 9 represents this strong relationship between the belief and the two actions implemented by Rodrigo in the form of a tree diagram.

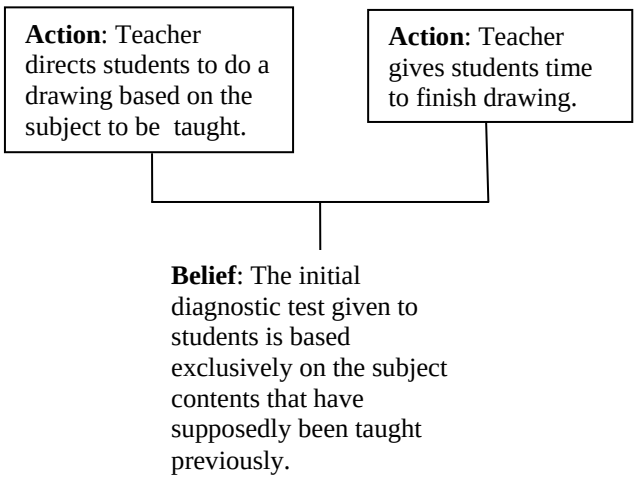

Figure 9. Tree diagram representing the relationships between a belief and two actions implemented by Rodrigo, referring to the script *Establishing previous knowledge of topic via a drawing activity*.

Regarding the scripts for *Organisation of content via chart*, it can be seen in figure 10 that there is a single unifying belief underpinning the complete sequence of actions that Rodrigo implements. This is accounted for by the fact that it is this belief that determines the organisation of the subject contents, which are then transmitted in the form of an exposition, which itself draws on organisational and expository strategies aimed at engaging the students.

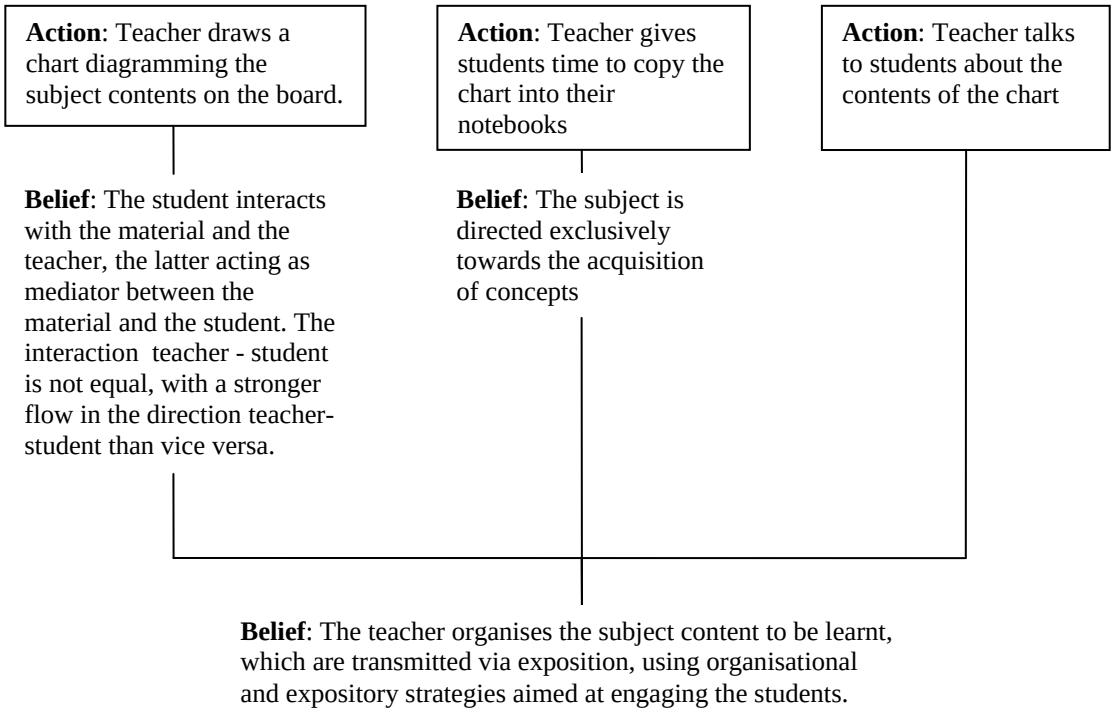

Figure 10. Tree diagram representing relationships between Rodrigo's beliefs and actions in respect of the script *Organisation of content via chart*.

The tree diagram also includes the belief that the student interacts with both the material and the teacher, but that there is a stronger flow from teacher to student than vice-versa, a belief which conditions Rodrigo's action [The teacher draws a chart diagramming the subject contents on the board]. With respect to the action [Teacher gives students time to copy the chart into their notebooks], this is associated with Rodrigo's belief that the subject is exclusively oriented towards the acquisition of concepts. When Rodrigo initiates the first action [Teacher tells students to do the activity in the book relating to the subject content] in the script *Memorisation of content through book-based activity*, it is evident that Rodrigo is guided by his belief in the importance of students articulating their understanding of the subject contents, and that in doing so they demonstrate the outcome of their learning.

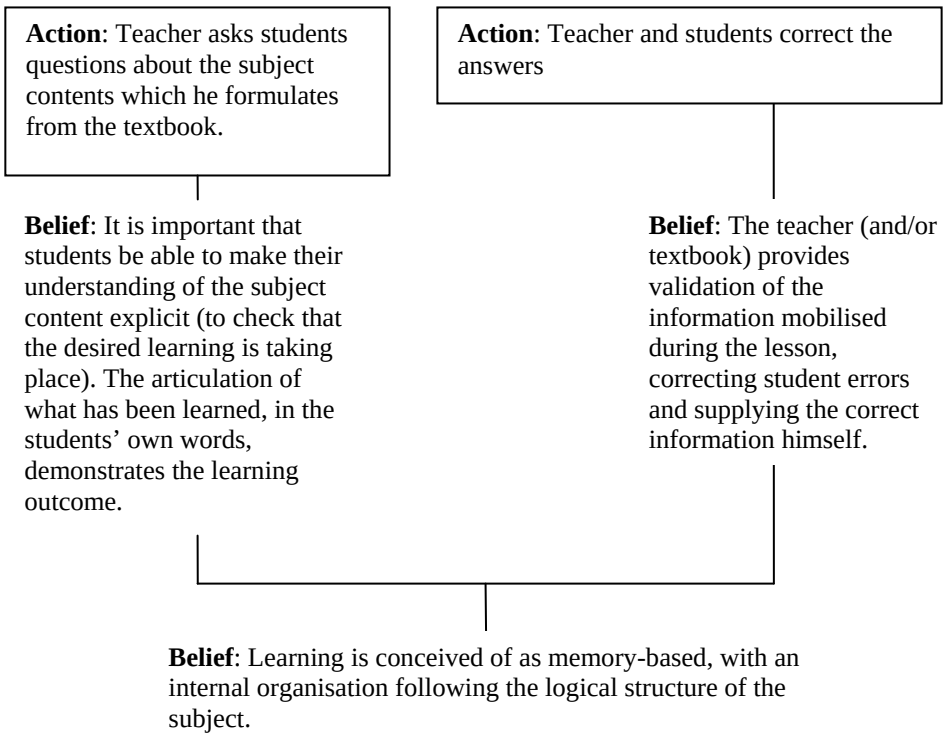

Figure 11. Tree diagram showing the relationships between Rodrigo's beliefs and actions in relation to the script *Memorisation of content through book-based activity*.

When he implements the second action of the same script [Teachers and students correct the book-based activity], Rodrigo shows that he is conditioned by the belief that it is the role of the teacher and/or textbook to provide validation of the ideas and information which are mobilised in the course of the lesson, correcting errors and supplying the correct information where appropriate.

4. Conclusions and implications for training

Through the process of modelling teaching, we have been able to identify underlying scripts, which in turn highlight the existence of, and relationships between, elements of Rodrigo's cognitions. Beliefs, objectives, knowledge and actions give substance to these theoretical entities, bounded by the so-called triggering and terminating events. The capacity to identify scripts represents an important step towards understanding teaching from the classroom actions themselves and from the cognitions which both researchers and teachers can derive from them. The awareness of such aspects underlying their actions as beliefs, objectives and knowledge is a vital component of reflective practice and of an enhanced understanding of one's teaching style. By this means teachers can construct new action sequences or even remodel their existing scripts to incorporate more innovative or desirable features whilst maintaining their compatibility with the action.

Further, understanding practice (in terms of the configuration of such guides, for example) is a starting point in engaging in theorising teaching for practical purposes (Skott 2006). Indeed, one application of such action guides is their use in providing

theoretical scaffolding (AUTHOR 1 et al. 2008) for defining and demarking problem areas within educational practice, and for achieving a better understanding of how these might have arisen. Here, we do not refer to a linear and immediate application of the outcome of such a theorisation, but rather to its role in teacher training or professional development, or as the focal point of the process of individual reflection.

". . . a theoretical loop [begins] with practice and potentially [provides] data for practice, not in terms of prescriptions for teacher performance, but as points of interest or reference schemes for the teacher's reflection" (Skott 2006, p. 1527).

As a result of the modelling process a hundred and three scripts were identified as employed by the novice teacher over a period of three and a half months of classes. These scripts were grouped into seven broad categories, thus: *Establishing previous knowledge*, *Interactive exposition of subject content*, *Review of subject content*, *Memorisation of subject content*, *Elaboration of subject content*, *Organisation of subject content* and *Evaluation of subject content*. However, the scripts vary in their details according to the specific topic within the curricular area (*Plant Diversity*) and the resources that the teacher used for the purposes of diagnosing, presenting, elaborating, organising or evaluating the subject content.

The script *Establishing previous knowledge of topic – the structure of flowers – via a drawing activity*, activated in order to identify contents previously taught, could, we believe, be equally used for establishing existing student conceptions of environmental problems, as described by Barraza (1999) or of salt marshes, as in AUTHOR 1 (2001). The student drawings could become a creative activity whereby the students' ideas are transformed into problems for subsequent classroom inquiry.

The second script, presented in the above section, *Organisation of content – Components of the structures for support, protection and reproduction of flowers – via*

a chart would be enriched were the teacher to guide the students towards working out their own conceptual relationships between the parts of a flower and diagramming these in their own mind-maps, following Novak and Gowin's (1984) guidance for meta-learning.

There are also several examples of scripts employed by Rodrigo which could be considered to act as potential obstacles to the development of his teaching. Such is the case of the script *Memorisation of subject content via a plant gathering activity outdoors* in which the activity is employed as an illustrative exercise or as a means of confirming previously taught content, as opposed to a motivational and investigative fieldwork experience, as the majority of teachers would it to be (Morcillo et al. 1998).

Another potential obstacle is the teacher's reliance on the script *Review of subject content via the reading of a text*, which is underpinned by a conceptualisation of learning as memorisation, internally organised according to the subject's structural logic, and as such removes the focus of learning from the student (Martínez at al. 2002). The teacher also habitually resorts to use of the script *Interactive exposition via the reading of a book*, and again the repeated deployment of the script might lead one to speculate whether opportunities are being missed to generate sequences of actions involving alternative didactic materials (De Pro Bueno 1995) or using the textbook in a more innovative way (Cachapuz & Praia 1998).

Finally, beyond raising Rodrigo's awareness of the key scripts above in order to assist the process of his professional development, we also believe that by contrasting his scripts with those of other teachers he could find alternative scripts more consonant with his beliefs, goals and/or knowledge, or reconstruct his scripts to incorporate more innovative or desirable aspects, whilst remaining serviceable.

The above comments regarding enhancing the action guides should be understood as alternative proposals, which would have the role of items for teachers to reflect on in workgroups, and never as prescriptions or fixed guides handed down by the researchers.

In general, by drawing on a constructivist approach to teaching and promoting meta-reflection through collaborative work (Climent & AUTHOR 2 2002, 2003a, 2003b), a teacher can transform his or her action guides. In any case, any attempt at incorporating new elements into one's teaching will necessarily undergo an ongoing and contextualised process of questioning and analysis. Furthermore, reflection *on* and *about* action (Schön 1987) and *for* action must translate into a conscious reconstruction of ever more flexible and complex action guides, and hence paradoxically less routine. Nevertheless, such action guides must preserve their defining functionality and retain a certain degree of standardisation whilst being open to reformulation.

Although no commitment regarding professional development was required of the teacher participating in the study, for which reason its scope is limited to his particular thinking at the time of the study, the researchers' interest goes beyond the cataloguing of the associations between his cognitions and actions, to encompass models which might offer advances in research into professional development.

The tree diagrams which were derived from the scripts are not intended to convey a positivist interpretation of causal relations between beliefs and actions. In other words, we do not claim that the teacher's belief in presenting content in the way he does directly brings about the corresponding action sequence, but that this relationship is one which was observed and extracted from the structures of the action presented above. It is important to be aware of the futility of attempting to apply mechanisms of cause and effect to the complex phenomena which comprise education.

But nor is any less true that the process of exploring and detecting strong relationships makes a significant contribution to understanding these phenomena. Obtaining such strong relationships provides us with just one (a not inconsiderable number) of the variables in the educational equation - to be understood here as facet or aspect rather than given a statistical interpretation.

Today most educational agents agree with the idea that classroom practice is a fruitful means of building teachers' professional development (Lieberman 1996). The modelling of teaching enables teachers to identify their own scripts and, consequently, to have the opportunity to access the beliefs (goals and knowledge) underlying their action.

Studies by AUTHOR 1 et al. (2008a) show that science teachers also present a diversity of scripts, which were either developed during their own teaching or experienced as students during their training.

We concur with Porlán et al. (2002) when they note that it is of great importance to analyse the obstacles and difficulties facing teacher educators in assisting trainees and teachers to consciously tune their practice.

The awareness of scripts by science teachers, maybe through the act of questioning and repeatedly analysing one's scripts (and tree diagrams) as a form of reflection on one's practice, is of crucial importance to their professional development not only because it can lead to an improvement in their classroom practice, but also because it can enable a more sustainable decision making[3].

[3] The notion of awareness is central to our conceptualisation of professional development, in which teacher reflection is considered a core descriptor (Climent & AUTHOR 2 2003; AUTHOR 2 & Climent 2006; Muñoz-Catalán et al. 2007).

Finally, although this paper has taken an analytical approach to the use of scripts, it is not difficult to envisage their use as an instructional strategy in the context of teacher training and professional development. To this end, teachers involved in in-service programmes or other collaborative environments might implement the MI as a means of reflecting on their own or others' practice. Indeed, the MI would be equally useful in pre-service training during teaching practice and as a source of simulated cases for study in seminars.

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