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Pedagogy Analysis Framework: a video-based tool for combining teacher, pupil & researcher perspectives

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ABSTRACT

Background: dialogue between the teaching profession and researchers regarding pedagogical strategy is sometimes problematic. Pedagogy research may benefit from incorporating research methods that can investigate teachers' and pupils' interpretations.

Purpose: this research expands the Pedagogy Analysis Framework (Riordan, 2020) by explaining in detail the meso-strategies (tactics) and a macro-strategy (grand strategy) used by participants in three school science lessons about chromatography. The research design builds on previous work by using full lessons and introducing pupil group verbal protocols. In addition, Pedagogy Analysis Notation is introduced to help understand and explain macro-strategic behaviours.

Sample: one class of thirty 13-year-old pupils and one science teacher.

Design and method: four research methods were used (lesson video analysis, teacher verbal protocols, pupil group verbal protocols and researcher group interviews). Data were video recorded (managed using NVivo). Fourteen hours of video data were analysed using Grounded Theory Methods by two educational researchers and the class teacher. The interpretivist theoretical perspective (symbolic interactionism) was underpinned by a social constructionist epistemology (hence the methodology is Straussian Grounded Theory). Appropriate criteria for evaluating the emergent grounded theory were used. Data were recorded in 2017.

Results: the Pedagogy Analysis Framework uses the concepts: means (human and non-human), strategy (a spectrum from micro-strategies (actions), through meso-strategies (tactics) to macro-strategies (grand strategies)), ends (regarding the self, another person or a thing, or a group of people or things), and accidents. Types of tactics identified in these data were: inform (misinform and disinform), question, instruct, use space/time, repeat, train, assess, and interact. Pedagogy Analysis Notation is used to understand and explain 'the stationary [sic] cupboard' incident.

Conclusion: the extended Pedagogy Analysis Framework, combined with the Pedagogy Analysis Notation, improves strategic dialogue between teachers, pupils and educational researchers. This research design facilitates comparison of interpretations of classroom pedagogy by a teacher, pupils and two researchers.

KEYWORDS

Video-based; pedagogy; analysis; strategy; grounded theory

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Introduction

Any lesson is complicated, so untangling what is happening in real-time is a challenge for any teacher however experienced. Improving our understanding of classroom pedagogy, and our ability to explain subtle interactions, could help both experienced and novice teachers become better educational strategists. The term 'pedagogy' is disputed in the literature and hard to define (Simon 1981; Alexander 2004, 2008; Black and Wiliam 2018). After a brief discussion below of this slippery term, this paper argues for an understanding of pedagogy focused on the interactions between people, and between people and things in the classroom (Hallam and Ireson 1999). Similarly, 'strategy' is a notoriously elusive term (Freedman 2013). We agree that researchers, 'should focus more on teaching strategies for conceptual change' (Lin et al. 2016, 2632), but argue that establishing what strategy means here is no easy matter for teachers or researchers. Building on previous work (Riordan, 2020) here we understand strategy as the way means are used to achieve ends. We see strategy as a spectrum from simple actions like raising a hand, though tactical behaviours involving well-known sequences of actions (like repeating what a pupil has said) to sophisticated interactions we term 'grand strategy' which can be described using a thick description and the Pedagogy Analysis Notation to be introduced later. We understand strategy as one element within the Pedagogy Analysis Framework, and during previous work explained some ways the strategies of participants influence pedagogy as it unfolds (Riordan, 2020). The word 'tactic' comes from the Greek *taktike* meaning 'arrangement', and 'strategy' from the Greek *stratēgia* meaning 'generalship'. Military metaphors were used by teachers in a previous study (Riordan, 2020) and then incorporated into the analysis (a process called theoretical integration in grounded theory). Other metaphors for communication are possible according to Krippendorff (1993), but he argues that a war metaphor works best when there is something to gain or lose in an exchange. Participants in classrooms have much to gain and lose, so, this military language may occasionally be appropriate but must not, of course, be taken too far as classrooms are not battlefields (Saltman and Gabbard 2010).

The purpose of this paper is to test and further develop the Pedagogy Analysis Framework (Riordan, 2020) in a naturalistic context. This research design for video-based pedagogy analysis involved normal school lessons. Furthermore, this study also incorporated pupil group verbal protocols in addition to teacher verbal protocols, and the teacher watched the whole lesson back rather than using video clips. Also, the teacher and two educational researchers coded the data so that interpretations can be compared. Thus, several of the limitations of previous work (Riordan, 2020) are being addressed. The research questions are:

(1) How can the pedagogical strategies used by participants in three consecutive science lessons be understood and explained?
(2) What are the benefits and limitations of combining video-based lesson analyses by multiple participants (teacher, researchers, and pupils)?

This paper first outlines our theoretical approach, including what we know, and what we do not, before explaining the research design. We then present our results before discussing the limitations of this work and potential next steps.

The theoretical approach

What we know

Pedagogy is a contested term (Watkins and Mortimore 1999). The focus of pedagogy can be on the pedagogue:

> pedagogy is the act of teaching together with its attendant discourse of educational theories, values, evidence, and justifications. It is what one needs to know, and the skills one needs to command, in order to make and justify the many different kinds of decision of which teaching is constituted. (Alexander 2008, 47)

This definition identifies many of the important factors at play in the complex social context of any classroom. Whilst Alexander obviously understands the importance of the learner in pedagogy, he chooses in this definition to keep the focus on the teacher. In contrast, pedagogy can be understood as a social phenomenon. Indeed, the Greek *paidagogos* refers to a servant who accompanies learners, where pedagogy is referring to the interactions between a leader and those led.

> [Pedagogy involves] those factors affecting the processes of teaching and learning and the inter-relationships between them. (Hallam and Ireson 1999, 78, quoted in Black and Wiliam 2018, 555)

In this definition the interactions between participants are correctly identified as important, but the interactions between people and the material objects in the room, and from which the room is constructed, are not highlighted. We understand pedagogy to be the set of incidents (including learning) that occur when learners and teachers interact with each other and with objects in the material world through time. For a discussion of the importance of the material in pedagogy please see Hardman, Riordan and Hetherington (in press). Participants and objects can be both physically present and/or imagined. Pedagogy has also been construed as a goal-orientated endeavour seeking political or economic gains, in contrast to the more disinterested subject of 'education' (Hinchliffe 2000). Ideologies influence teaching and learning (Van Dijk 1998), but the aforementioned instrumentalist definition is too narrow for our purposes. Part of the fun of teaching is managing ideological conflict. This present research adopts, therefore, a social understanding of pedagogy, whilst welcoming Alexander's broad vision of the concept and acknowledging micro and macro political influences on classroom behaviours.

Pedagogy analysis, the subject of this paper, seeks to untangle the cognitive, affective, motivational, and social behaviours of all participants in a classroom as they interact with themselves, each other and with things (including the objects present and fabric of the room). Hence, following Illeris (2007), the learning of both pupil and teacher during a lesson is here understood to involve cognitive, affective, and conative processes, enacted on both individual and group scales.

> [Learning is] any process that in living organisms leads to permanent capacity change and which is not solely due to biological maturation or ageing. (Illeris 2007, 3)

The Pedagogy Analysis Framework (Riordan, 2020), which this present research extends, is a type of problem-solving heuristic called a means-ends analysis (Davidson, Sternberg, and Sternberg 2003). Thinking can be categorised into 'problem solving' involving the

search among potential options to achieve a goal, and 'reasoning' where logical rules are used to derive conclusions. Furthermore, problem solving can be further subdivided into algorithms (a procedure certain to lead to a solution if followed correctly) and heuristics.

> [Heuristics are] an informal, intuitive, speculative procedure that leads to a solution in some cases but not in others. (Berlyne, Vinacke and Sternberg 2008)

Different sorts of problems lend themselves to either heuristic or algorithmic problem-solving strategies. Assumptions of this present research are that pedagogy in real classrooms is not a problem to be solved with an algorithm, but pedagogical heuristics (like the Pedagogy Analysis Framework) may sometimes help teachers and educational researchers. No plan survives the classroom. Pedagogy analysis in this study involves heuristic problem solving by researchers, teachers and pupils about the problem-solving participants do before, during and after lessons. Pedagogical problems do not have clear solution paths (they are 'ill-structured'; Simon 1973; Reed 2016), often occur simultaneously and are cyclical (i.e. the output from one problem becomes part of the input to the next; Pretz, Naples, and Sternberg 2003). The Pedagogy Analysis Framework (Riordan, 2020) uses the concepts: means (both human and non-human), strategy (on a spectrum from micro-strategies (actions), through meso-strategies (tactics) to macro-strategies (grand strategies)), ends (regarding the self, another person or a thing, or a group of people or things), and accidents. Hence, we use the word strategy as an umbrella term for actions, tactics and grand strategies. Actions are simple movements of the body (or a part of the body), or participants interacting in some way with an object or objects. Tactics are recognisable sequences of actions enacted by one or more participants. Types of tactics identified in previous work in order of frequency used were: question, instruct, inform (misinform and disinform), use space/time, repeat, train, assess, and interact (Riordan, 2020). A grand strategy involves a complicated interaction between participants (usually including participants interacting with objects too) where a thick description is necessary to untangle the pedagogy (see the results below for an example).

What we do not know

Conceptual change pedagogy researchers have found it hard to influence classroom practice (Duit, Treagust, and Widodo 2013). The present research argues that one reason for this is a lack of a shared vocabulary between teachers and researchers for understanding and explaining the context within which interventions occur. The Pedagogy Analysis Framework (Riordan, 2020) sought to fill that gap, and this paper expands the framework by identifying tactical interactions between people, and between people and the material objects in the room (including those from which the room is constructed, and imagined people and objects). Identification of the tactical detail in real classroom lessons illuminates the heuristic problem solving by teachers and pupils.

Furthermore, this paper argues that macro-strategic interactions between participants are often so complicated that teachers, especially novice teachers, and researchers would sometimes benefit from representing these interactions using the Pedagogy Analysis Notation which we introduce. Case studies such as the one presented in this paper, illustrated using this Pedagogy Analysis Notation, could be useful in video-based Initial

Teacher Education where it can be challenging for teacher educators and school-based mentors to help student teachers to notice what is happening during particularly complicated sections of lessons (Sherin and Van Es 2005).

Research design

The theoretical perspective and epistemology

The research design had an interpretivist theoretical perspective (symbolic interactionism) and was underpinned by social constructionist epistemology (Clarke 2003, 559). Corbin and Strauss (2008, 2) acknowledge symbolic interactionism and pragmatism as the philosophies which underpin their version of grounded theory. Hence the methodology in this current study is Straussian Grounded Theory. Symbolic interactionism can be seen in the research methods. For example, what the participants appeared to have understood emerged during teacher verbal protocol interviews, group pupil verbal protocol interviews and when the teacher used NVivo to analyse his video data. Grounded theory methods will be explained briefly below in the section called 'Data collection and analysis'.

Research methods (Data collection and analysis)

The four research methods used were lesson video analysis, teacher verbal protocols, pupil group verbal protocols and researcher group interviews. The three lessons, each lasting approximately one hour, occurred as they would normally in the school year, with the only changes being the presence of three video cameras, one of which had a 360-degree microphone attached, with another which was connected to a lapel microphone worn by the teacher, and the attendance of two researchers sitting at the back. Two of the cameras were positioned at the front of the room on either side, and one was at the back in the middle. The teacher was encouraged to plan and teach as they would normally. Analysis began as soon as the first lesson had been recorded and continued after the end of data gathering (the grounded theory process called 'concurrent data collection and analysis'; Birks and Mills 2011). Previous work (Riordan, 2020) used teachers working with small groups of six pupils, so this present study extended that work by using three ordinary secondary school science lessons on Chromatography.

There was a delay between each lesson and the follow-up teacher and pupil group verbal protocol interview to allow time for analysis and to prepare the video clips which were used as prompts for the pupil group verbal protocol interviews. This and other limitations of this work will be discussed later. The teacher was video recorded for about two hours whilst making verbal protocols of each lesson, which again was an extension of previous work where only clips were used as prompts with the teachers (Riordan, 2020).

Pupil group verbal protocols were introduced as a research method in this study and allowed pupils to analyse their lesson. Video clips from the relevant lesson were used for the pupil group verbal protocol interviews for pragmatic reasons. Video clips for the verbal protocol interviews were selected using the following criteria: where a pupil had expressed something that a researcher, or the teacher, wished to be clarified; where one of us wanted to compare a researcher/teacher interpretation with that of a pupil; and/or

where we were not sure how to understand an interaction during a lesson. As findings emerged, these influenced the selection of clips used in subsequent pupil group verbal protocol interviews (a grounded theory process called 'theoretical sampling'). The rationale for the selection of the clips evolved during the study (yet another grounded theory method called 'constant comparative analysis'). Researcher group interviews were also video-recorded and analysed, and included the class teacher.

With this combination of research methods, insights from the multiple perspectives of pupil, teacher, and researcher into the same lesson could be considered and compared. Hence findings could be corroborated using triangulation from different sources, methods, and investigators (Carter et al. 2014). Combining verbal protocols with interviews was originally proposed by Taylor and Dionne (2000), and it is known in the literature that such an approach can give an extremely rich data set (Pressley 2000). All fourteen hours of data were video-recorded and managed using NVivo 12 pro. Lewins and Silver (2007) argued NVivo is the most suitable software, among those available, for a grounded theory study.

Grounded theory methods were used to analyse these data. The present study built on a previous study with some similarities in research design (Riordan, 2020) and used the following grounded theory techniques:

> [Initial] coding and categorization of data; concurrent data generation or collection and analysis; writing memos; theoretical sampling; constant comparative analysis using inductive and abductive logic; theoretical sensitivity; intermediate coding; selecting a core category; theoretical saturation; and theoretical integration. (Birks and Mills 2011, 9).

Initial coding involves labelling potentially significant words or phrases ('incidents') in the data. This pragmatic approach to coding is recommended by Bryant and Charmaz (2019). We each grouped, ungrouped, and renamed categories (intermediate coding), before identifying key themes (selective coding). After recording each set which was comprised of a lesson, a teacher verbal protocol interview, a group pupil verbal protocol interview and a group researcher interview, that set was analysed before the next set of interviews was conducted (concurrent data collection and analysis). Theoretical ideas recorded throughout the research (memos) by the researchers and the teacher were used to build the Pedagogy Analysis Framework described in the results section later (theoretical integration). We acknowledge that our abilities, as researchers, to identify instances and relations changed and deepened as the study progressed (termed 'theoretical sensitivity' in grounded theory). We continued using the grounded theory methods until we thought no new insights would emerge and we had many examples of our categories (this is called 'theoretical saturation'; Bloor and Wood 2006).

Participant selection

One class of thirty 13-year-old pupils took part and one science specialist teacher (an Advanced Skills Teacher and physics specialist). The teacher was recruited from amongst participants in a previous study (Riordan, 2020), so a convenience sample was used. This had the advantage that the teacher was already familiar with the process of doing verbal protocols, but the potential influence of the previous study on this participant represents a limitation of this current work to be discussed later. As the theoretical perspective is interpretive, a small sample was used so that data could be examined in considerable

detail. The research methods generated over 14 hours of video in total, so practical considerations like time available also influenced the sample size. Three groups of 13-year-old pupils participate (three girls and three boys) in each pupil group verbal protocol interview. These pupils were volunteers from the lessons (the same group of pupils each time with one change for one interview because a pupil was absent).

Trustworthiness

Criteria for evaluating qualitative research like this present study were defined by Lincoln and Guba (1985).

> The four terms 'credibility', 'transferability', 'dependability' and 'confirmability' are … the naturalist's equivalents for the conventional terms 'internal validity', 'external validity', 'reliability' and 'objectivity'. (*ibid*., 300)

We used the same techniques proposed by Lincoln and Guba (1985, 219) for establishing trustworthiness in this study as discussed in Riordan, (2020). These techniques include triangulation (sources, methods, and investigators), thick description (Geertz 1973), auditing the study in an NVivo file (available on request), using memos, etc. For further detail on this please see Riordan (2020). We argue that the techniques of Lincoln and Guba (1985) used alongside grounded theory methods, can give trustworthy evidence.

Ethics

As pupils and a teacher participated in this study, we followed the guidelines from the British Educational Research Association (BERA, 2018). The teacher was invited to participate directly. Formal permission to do this research was then requested by letter to the Head Teacher. Pupils were first informally invited to take part by the teacher. Those interested were given letters with reply slips for their parents or guardians. Pupils were also written to and asked to fill in a consent form, to ensure informed consent. Regarding confidentiality, the pupils are referred to using only initials here.

Results

Previous work, Riordan (2020), found that Pedagogical strategy can be understood as how a participant uses the means at their disposal to try to achieve or avoid ends, and that it can be useful to identify a strategic spectrum varying from the micro-scale (actions), through the meso-scale (sequences of actions; here called tactics) to a macro-scale (here called a grand strategy). The previous study also noted that a 'thick description' is necessary to explain a grand strategy (Geertz 1973; Blaikie and Priest 2019) and that accidents involve unwanted means, unwanted strategies, and/or unwanted ends. Accidents happen frequently and are often significant. New findings from this present study are that tactics identified in these data in order of frequency were: inform (misinform and disinform), question, instruct, use space/time, repeat, train, assess, and interact. The frequency of occurrence of these tactics is illustrated below in Figure 1).

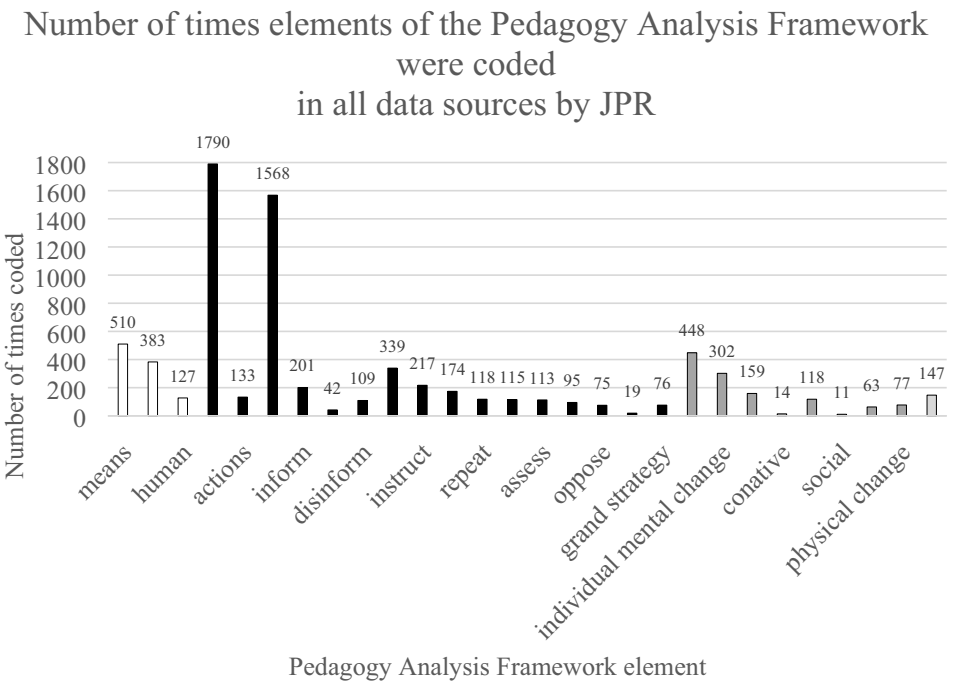

Figure 1. A graph of the number of times each element of Pedagogy Analysis Framework was coded in all data sources.

Next, we will exemplify each of the eight types of tactic identified above using three lesson transcript excerpts, then a thick description of a passage from one of the lessons will be used to show how tactics like these were combined into behaviour we call 'grand strategy'. Then a Pedagogy Analysis Notation will be introduced as a visual representation of grand strategy and an alternative to thick description. We argue that the Pedagogy Analysis Notation can work well alongside a thick description and we are not suggesting this as a replacement.

The following three lesson transcript excerpts illustrate the eight types of tactic identified in these data. The first includes examples of the tactics; **instruct, inform, train, repeat** and **question**:

L2 23:57 **DC (teacher)**: [Name of pupil] I think yours might be [a good answer]. Tell me about what you justified at the bottom of your page.

L2 24:01 P_1: Um. [Quietly]

L2 24:03 **DC (teacher)**: Shout loud.

L2 24:06 P_1: Um. [Reading from a photo of an answer P_1 wrote onto a mini-whiteboard the previous lesson displayed on the Interactive Whiteboard] To see and be able to measure the distance the colours have separated as the pencil line wouldn't dissolve.

L2 24:14 **DC (teacher)**: Lovely. Thank you. The pencil line doesn't dissolve. Some people use the word lead [DC mimes writing with a pencil], which is fine because we say that at home. We say the pencil is made out of lead. But it isn't, it's made of . . . [DC pauses and points at three different pupils]

L2 24:25 P_2: Graphite.

L2 24:26 **DC (teacher): . . .** graphite. And two or three people put graphite.

In the following discussion, tactics are shown in bold. Tactics are behaviours that teachers and learners use regularly during lessons. First (L2 23:57) the teacher **instructs** the pupils to do something (to tell him about something they have done). Next the pupil **informs$_1$** the teacher of what they had written the previous lesson. The teacher then **trains** the pupil who had answered using praise (in the sense of operant conditioning), and then **repeats$_1$** what the pupil has just said. The teacher **informs$_2$** the pupils that the centre of a pencil is sometimes called the 'lead', that this is reasonable everyday language (**inform$_3$**), and that this is not made of the metal lead (**inform$_4$**). He then asks a **question** about how this would be termed by scientists. The type of question here is what Chin (2007) describes as a 'verbal cloze' where the teacher stops speaking to let a pupil finish the sentence. After a pupil gives the correct answer (another **inform$_5$**) the teacher **repeats$_2$** this to confirm that it is correct. The teacher then **informs$_6$** the pupils that some of them had given this correct answer previously. Hence in 29 seconds, eleven tactics are used of five different types.

The second excerpt illustrates the tactics; **misinform** and **interact** (oppose).

L1 15:42 **DC (teacher)**: [. . .] Who can give me some advice as to what I should have done to get a nicer better [DC pauses]. What's it called?

L1 15:48 P_3: Chromatography.

L1 15:50 **DC (teacher)**: Chromata . . . [DC pauses]

L1 15:51 P_4: Chromatography paper.

L1 15:53 **DC (teacher)**: [DC holds his ear with his finger and leans towards P_5]

L1 15:54 P_5: Chromatogram.

L1 15:55 **DC (teacher): . . .** gram. How could I have got a better chromatographa . . . [DC stumbles, possibly playfully, over the word] that. [DC points to the word on the board]. [P_6 name] what do you reckon?

L1 15:59 P_7: [Starts to answer]

L1 16:00 **DC (teacher)**: [To P_7] Your name ain't [sic; P_6 name].

The pupil answer in L1 15:48 (P_3) of 'chromatography' is not correct, and this is coded as the tactic '**misinform**' in this study (a subset of the tactic '**inform**' that also includes '**disinform**'; see below). The answer in L1 15:51 is correct but is not the technical term that DC appears to be looking for (i.e. 'chromatogram'). In answer to DC's question in L1 15:53 a pupil (P_7) who has not been chosen to answer starts to speak. The tactic '**interact**' comes in two subtypes: **oppose** or **collaborate**. The answer from DC in L1 16:00 can be interpreted as '**interact**' (of the type op**pose**) as the teacher makes clear to the pupil who has spoken out of turn that this is not acceptable.

The final excerpt includes an example of the tactics: **question, use time/space, disinform** (as in the use of disinformation) and **assess** (to get information and use it for immediate pedagogical purposes).

L2 55:17 **DC (teacher)**: [P_3 is at the front of the class writing the Rf value calculation on the Interactive Whiteboard] Lovely. Anything else? You looked like you were hesitating there. [Pause] What did I think maybe she was going to do and get wrong?

L2 55:24 P_4: Write something?

L2 55:26 **DC (teacher)**: Yes. What do I think she was maybe going to write that would have been wrong? [Long pause] No? [Turning and speaking to P_3] Well done for not falling for my cunning trap. I thought you were going to write a unit. Why does it not have a unit?

L2 55:38 P_3: Because it is a factor?

L2 55:41 **DC (teacher)**: It's a factor. It's a ratio. Yes. Brilliant.

At the beginning of this excerpt (line L2 55:17) the teacher **assesses** P_3 using a **question** about whether she has missed anything in the answer she has just written on the board. The correct answer is, 'no' because this quantity (the Rf value) is dimensionless. The pauses in L2 55:17 and L2 55:26 are examples of the tactic '**use space/time**'. Later (L2 55:26) the teacher makes it clear to the pupils that this was a trap, and praises P_3 for not 'falling in'. The tactic '**disinform**' is to use deception which is 'a distortion of perceived reality' and there are two types; dissimulation (hiding the real) and simulation (showing the false) which can be further subdivided (Whaley 1982, 182). The three types of dissimulation are masking (make invisible), repackaging (disguise) and dazzling (cause someone to lose clear vision). Three types of simulation are mimicking (through imitation), inventing (displaying a different reality) and decoying (diverting attention). DC is obviously aware that the quantity has no unit yet asks the pupil if they have missed something having written the quantity. The statement, 'anything else' (L2 55:17) can be interpreted as repackaging DC's real intention of establishing that this quantity has no unit. All six types of deception were identified in these data (see Table 1 below).

We acknowledge that these same transcript excerpts may be interpreted in other ways. The point here is not to claim that this interpretation is 'correct', but to argue that the terminology of the Pedagogy Analysis Framework can be useful in evaluating different interpretations of classroom interactions.

Many familiar with school teaching will recognise these eight tactics, and there is a huge literature discussing these tactics using a variety of terms (see for example Chin

Table 1. Number of times the six types of deception were identified in all data sources.

Type of deception	Number of sources	Number of times coded
Mask	7	12
Repackage	9	53
Dazzle	2	2
Mimic	7	14
Invent	8	12
Decoy	4	4

2007 on questioning or Evans and Lee 2011 on deception in childhood). The originality of this work is discussed later. As illustrated in the examples above, much of what happens in classrooms is relatively easy to analyse in our experience, but some interactions are much more complicated. This can be seen in Figure 2 below which shows the Coding density of the three lessons.

The darker the shade, the more codes needed to analyse the interactions. Sporadic dark patches in these coding density graphs indicate when more sophisticated strategic behaviour emerged (here termed 'grand strategy') as illustrated next.

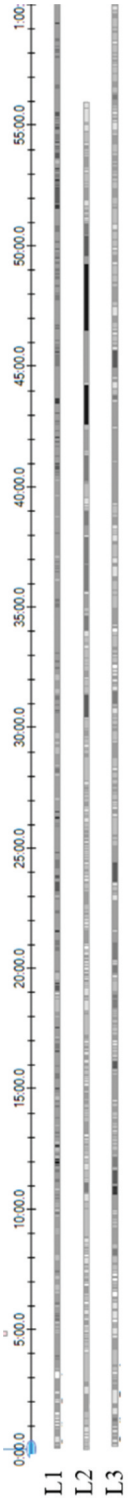

Figure 2. NVivo coding density for lessons 1, 2 and 3.

A thick description of 'the stationary [sic] cupboard' incident

The following transcript extract (L2 21:44–22:41) will be untangled using the Pedagogy Analysis Framework to illustrate the tactical constituents of one grand strategy. The subsequent 'thick description' explains the behaviour of participants, and the context within which it occurs, such that the behaviours exhibited can be understood (Geertz 1973). This extract is from the second lesson of three. A joke was told by the teacher (DC) during lesson 1 (L1 56:25–37) which we term the 'stationery phase [sic] joke$_1$' as the stationary phase in this experiment (a technical term in Chromatography for the medium that does not move) is made of stationery (i.e. paper). The following transcript retells joke$_1$ and then extends this idea by recounting a second joke$_2$. Someone has spelt a cupboard label incorrectly.

L2 21:44 **DC (teacher)**: [Pointing at the word 'paper' on the interactive whiteboard] So what is [it] that we should be adding to this one [DC points with his finger at the word paper on the Interactive Whiteboard] that tells us what it really is or really does? There's maybe two words, maybe one word of what that does.

L2 21:56 P_1: [unclear]?

L2 21:58 **DC**: Erm. It does, but it doesn't [accompanied by hand gesture]. So, no. There's something very different between these two [DC points to the word 'paper' and then 'water' on the board with his hand], and I think I made the bad joke about this one [DC points to the word 'paper' on the board with his hand] last week. I said I liked it because it was a pun. [P2 name].

L2 22:12 P_2: [unclear: possibly 'It doesn't move.'?]

L2 22:13 **DC**: Shout!

L2 22:14 P_2: [Louder] It doesn't [move].

L2 22:15 **DC**: Which one doesn't?

L2 22:16 P_2: The stationary one.

L2 22:17 **DC**: Good. The stationary one. And it was funny because it is also [DC pauses and gestures with his hand to indicate that the pupils should continue the sentence] . . .

L2 22:19 P_3: Paper.

L2 22:20 **DC**: Paper. Which is . . . [DC pauses again]

L2 22:21 P_4: Stationery.

L2 22:22 **DC**: Stationery. And if you go and look on one of the cupboards in the English office, they have spelt it wrong. They've got a stationery cupboard that is actually a stationary [DC mimes 'not moving'] cupboard, instead of a [DC picks up and shakes a pile of paper] stationery [slight pause] cupboard. [DC smiles, several pupils laugh in a slightly amused way. DC does a slight light shake of the head] No? [DC moves his flat hand held palm facing the pupils downwards quickly indicating amused exasperation] In which case [DC points with his hand to the word 'water' on the board] what is this one going to do? If this one is stationary [DC points with his hand to the word 'paper'], this one [pointing to 'water'] . . .

L2 22:40 Several pupils simultaneously: Moves.

L2 22:41 **DC**: Moves [with an emphasis in the voice]. Brilliant! [DC writes 'stationary phase' onto the Interactive Whiteboard underneath the word 'paper']

This passage can be interpreted in different ways, but here we focus on illustrating tactics within this example of macro-strategic behaviour (elements of the framework are highlighted in **bold**). The teacher begins this passage with a **question**$_1$ and a **gesture**$_1$ of

his finger towards the word 'paper' on the whiteboard (this board is a **non-human means**$_1$ on the wall to the right of the interactive whiteboard). The type of **question**$_1$ here appears to be what Chin (2007) would call 'verbal jigsaw: association of keywords and phrases'. Verbal jigsaw questions seek to help learners with scientific vocabulary. The teacher gives a clue to the number of words required (**inform**$_1$). The answer from the pupil$_1$ (another **inform**$_2$; unclear, unfortunately) results in the teacher telling (**inform**$_3$) the student that this is both correct and incorrect (accompanied by another hand **gesture**$_2$). At this moment, the teacher reminds pupils (**repeat**$_1$) of the joke$_1$ he told about the stationary phase the previous lesson (i.e. the stationary phase is stationery). Pupil$_2$ explains (**inform**$_4$) that the stationary phase does not move, which first results in the command to 'shout' (**instruct**), before a second teacher **question**$_2$ in line L2 22:15 (a type called 'Socratic question: pumping' by Chin 2007, by which the questioner elicits more information). The pupil$_2$ answer earns some praise (**train**$_1$) from the teacher before the teacher repeats the point (**repeat**$_2$). Next at L2 22:17 the teacher starts a sentence and indicates with a third **gesture**$_3$ that the pupils are to finish this. This type of **question**$_3$ is another 'verbal cloze' one (Chin 2007). The pupil's correct answer (**inform**$_5$) is **repeated**$_3$ by the teacher. The teacher then uses yet another verbal cloze **question**$_4$ to elicit that paper is stationery. Then the stage has been set for the teacher to tell (**inform**$_6$) the pupils the joke$_2$. Someone misspelt a label on a stationery cupboard, so it read 'stationary'. The teacher mimes something not moving with his body (an **action** with his own body as the **human means**$_2$). Paper on the table is shaken as a prop (another **gesture**$_4$ using a **non-human means**$_3$). The slowing of the speech and pause seems to be for dramatic effect. The joke does not provoke huge merriment (it is, after all, a 'teacher joke'), and the teachers' possibly feigned frustration and **gesture**$_5$ are part of the drama. Immediately the teacher asks two **questions**$_{5\ \&\ 6}$ in succession (a 'pump' followed by a 'verbal cloze'; Chin 2007). By L2 22:40 potentially more of the pupils can distinguish between the stationary phase (the paper) and the mobile phase (the liquid). This occasions more praise from the teacher (**train**$_2$) and the teacher writes a summary (**repeat**$_4$) onto the whiteboard (a **non-human means**$_3$).

As can be seen from the timeline, this interaction between the teacher, the pupils and the three non-human means (the board, the pile of paper, and the imagined stationery cupboard label) lasts 57 seconds. During it, we have just identified five different **actions** (gestures), and eighteen **tactics** (**inform** six times, six **questions** (of three different types), three **repeats**, two **trains** and an **instruct**). We argue that this is an example of a grand strategy as the thick description above is necessary to understand and explain the constituents (i.e. the actions and tactics). There is no suggestion here that participants would consciously categorize their strategic behaviours as they teach or learn, even if they had time. The concept of grand strategy acknowledges that understanding and explaining strategic interactions between participants, and between participants and things, in classrooms often requires deeper analysis than merely identifying actions and tactics. Nevertheless, the constituents of a grand strategy are actions and tactics. This passage was selected as an exemplar of a grand strategy, but in many ways, it resembles the other three hours of lesson video data.

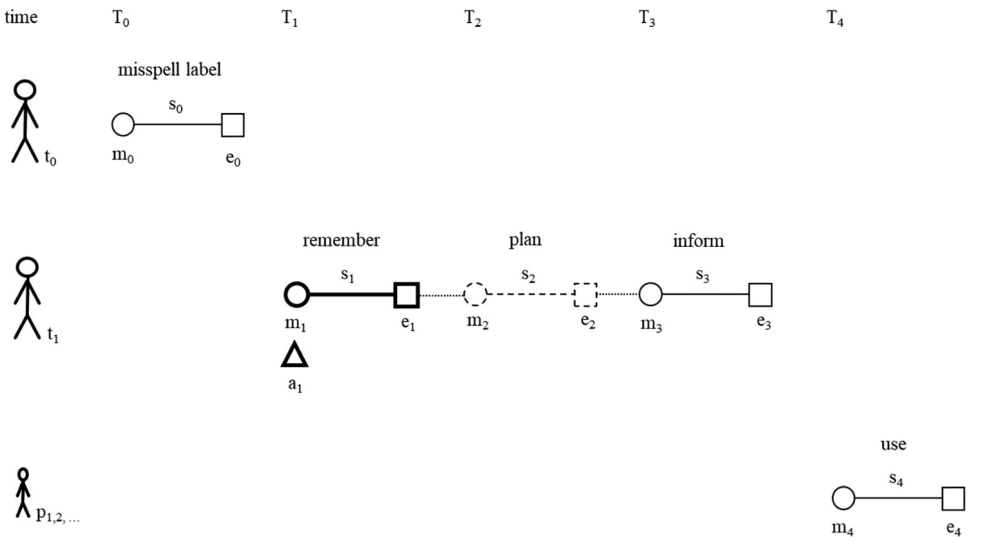

Figure 3. The 'stationery [sic] cupboard' example represented using the Pedagogy Analysis Notation.

Next, we give an example to illustrate how triangulation supported our interpretation of these data. A video clip of the 'stationery [sic] cupboard' joke$_2$ analysed above was watched and discussed by the pupils during the group pupil verbal protocol interview (VPP2 42:41–45:03). The italics in the following passage indicate the passage of the video clip from the lesson playing whilst the pupils watch.

L2 22:22 ***DC****: Stationery. And if you go and look on one of the cupboards in the English office, they have spelt it wrong. They've got a stationery cupboard that is actually a stationary [DC mimes 'not moving'] cupboard, instead of a [DC picks up and shakes a pile of paper] stationery [slight pause] cupboard. [DC smiles, several pupils laugh in a slightly amused way. DC does a slight light shake of the head] No? [DC moves his flat hand held palm facing the pupils downwards quickly indicating amused exasperation]*

L2 43:02 **P$_1$**: [Pupils, researchers and the teacher laugh politely] Yeah [with a smile]. So, sir thinks he's funny. [Everyone laughs a lot]

L2 43:07 **P$_1$**: [Again with a smile] But he really isn't. [Everyone laughs] Yeah but, he is helping us teach [with a small shake of the hand gesture for emphasis] because he is trying to make jokes which aren't that good [participants laugh] but it is helping us learn [with another small hand gesture for emphasis] so we'll always remember it [P$_3$ smiles].

These pupils during this pupil group verbal protocol interview clearly find the joke still amusing, and the gentle teasing of the teacher by a pupil (P$_1$) even more amusing, but this pupil also points out that this joke helps the group learn, in his opinion, and remember. Other pupils in this group later (L2 43:43) confirm that they agree with P$_3$'s point about the joke helping by nodding their agreement. This is one example of many where triangulation between the different data sources informs the interpretation (see the discussion later for more on triangulation).

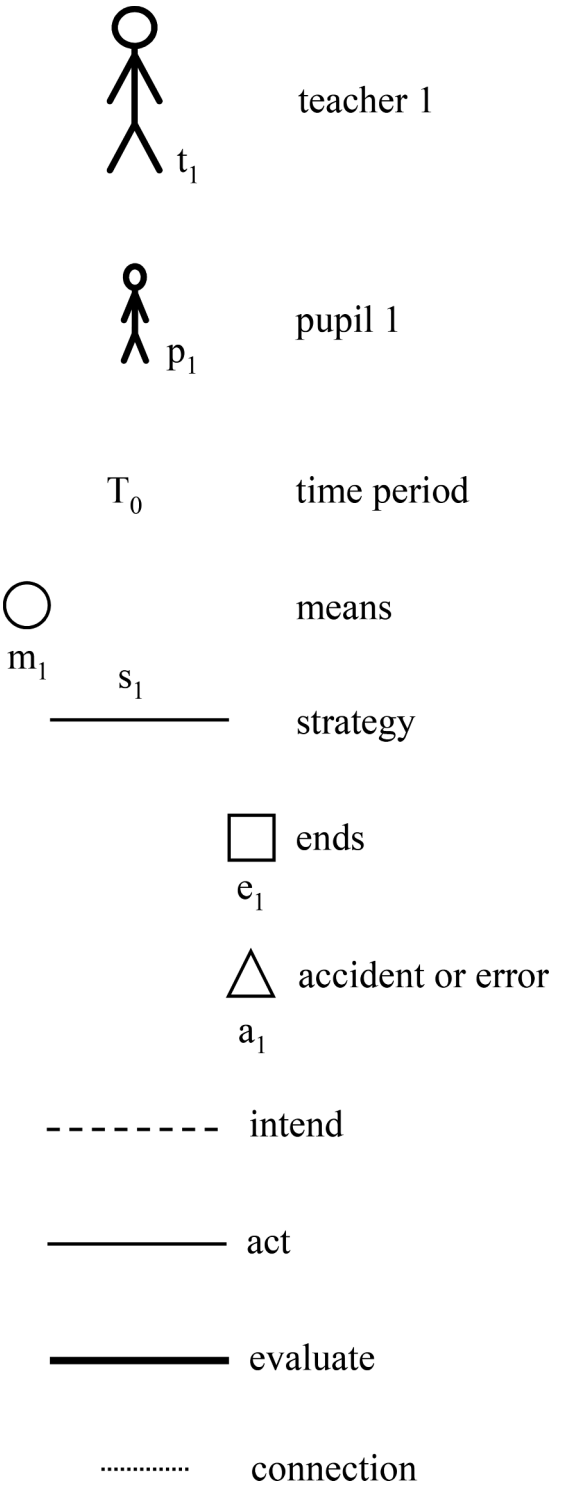

Figure 4. Key for the Pedagogy Analysis Framework.

The Pedagogy Analysis Notation

In Figure 3 below, we describe the stationary [sic] cupboard incident again, this time using symbolic representation. The key to this Pedagogy Analysis Notation is in Figure 4 below.

The 'stationery [sic] cupboard' example represented using the Pedagogy Analysis Notation

We argue that this Pedagogy Analysis Notation illustrates the key elements of the Pedagogy Analysis Framework as described in the thick description above. A teacher might understand pedagogy when articulated using the Pedagogy Analysis Notation and not with the thick description using the PAF, and vice versa. We think Pedagogy Analysis Notation Diagrams of simple and complicated pedagogical interactions, used alongside the corresponding thick description, and with the video clips of a variety of incidents from real lessons, could be useful tools when used in Initial Teacher Education, Continuous Professional Development of experienced teachers, and in pedagogy research. This claim would need to be tested in future research.

The 'goes by the colour' incident

To indicate how multiple perspectives help pedagogy analysis we now analyse briefly one short extract from a Teacher Verbal Protocol interview.

TVP2 1:12:10 – 1:13:36 **DC**: [DC has paused the lesson 2 video. PVP2 happened earlier that day] So in [lesson 1], the cricket boys went off – what was it? – halfway through. They missed the bit where we modelled the paragraph all together and then in the kids' video bit [i.e., PVP2] [P1] definitely admitted to [. . .] – said – stated, "I still don't know what's going on." The homework that I set them was a past paper question and they all had to do it, even if they were the cricket boys. And then they peer-assessed it according to the mark scheme at the beginning of [lesson 1]. And [P2], who was one of the proponents of, 'It goes by the colour.' His answer still talks about this thing. Erm. And he was still convinced he was right. Even with the mark scheme in front of him, and I can't from memory remember who I paired him with last lesson – Oh yes, it was [P3], and so [P3] and he had been discussing it [DC gestures something going back and forth with his hand] and so I went round and caught this wrong answer that he was trying to convince [P3] was right [DC laughs]. And gave [P3] a couple of tips of questions [P3] could ask to help [P3] out. But [P2] was still absolutely, "But that's what happens."

There is not space here for a full analysis of this passage (or the related ones from the three lessons, three PVP and three TVPs) using the PAF, but briefly it concerns a common 'misconception' about chromatography that the distances the inks travel depend on concentration (Bindis 2013, 224). DC explains in TVP2 that P1 revealed in PVP2 that even after the first two lessons he does not understand chromatography and clarifies that P2 has this misconception during lesson 1 and the 'written task with peer-review' **tactic$_1$** has failed to address this for P2. In the subsequent pair-work (**tactic$_2$**) between P2 and P3, the teacher 'caught [P2 expressing] this wrong answer', notes that P2 was attempting to convince P3 (**tactic$_3$**) and explains his [i.e. DC's] intervention to help P3

Table 2. The number of types of code used, and the number of times a code was used in all data sources.

Data source	Number of types of code used	Number of times a code was used
L1	200	2773
L2	131	3068
L3	165	3926
RC1	21	45
RC2	81	374
RC3	46	225
VPP1	37	102
VPP2	63	543
VPP3	86	691
VPT1	113	497
VPT2	86	559
VPT3	80	412
Total		13215

with questions to counter P2 (**tactic$_4$**). We argue that simple observation of a lesson without the use of multiple perspectives may not always reveal who knows what, when thinking changes, why participants act, and how they act.

Discussion

The findings illustrate how pedagogy analysis of classroom interactions is not straightforward, particularly during periods of a lesson when participants use grand strategy. The Pedagogy Analysis Framework can help understand and explain the pedagogy in these three consecutive science lessons. The entire data set for this project involved 13,215 coded incidents in 14 hours and 16 minutes of video data. This paper included four incidents as exemplars. In real-time, these four incidents lasted 2 minutes and 8 seconds in total (i.e. 0.25% of the data available). It will come as no surprise to those with classroom experience and/or those who do pedagogy analysis, that lessons are complicated but we hope the Pedagogy Analysis Framework will help understand and explain pedagogy, and thus aid dialogue between teachers and researchers.

Combining video-based lesson analyses by multiple participants (researchers, teacher, and pupils) helped us frequently during the analysis. This research suggests using a variety of different perspectives on the same data provides insights that may be missed if a single research method is used. In small scale qualitative research such as this, triangulation can improve the precision and accuracy of results (Flick 2018). Firstly, investigator triangulation, the use of multiple observers/investigators in a single study (Denzin 1970), mitigates against reliance on a lone investigator, and enables integration of different theoretical approaches and perspectives on the same data (Archibald 2016). Secondly, source triangulation involves using multiple copies of one type of source (for example teacher verbal protocols on several different lessons) and different sources of the same information (for example a lesson video, with the corresponding teacher verbal protocol and the researcher group interview data for the same participant teacher). Thirdly, method triangulation is present in this study because different types of data collection are used (observation of a teacher during a lesson, teacher verbal protocols, pupil group verbal protocol interviews and the researcher group interview). Fourthly, the grounded theory process of 'theoretical integration' (see the discussion) involves exploring the relations of the emergent grounded

theory with results obtained using different methodologies (theoretical triangulation). Finally, data analysis triangulation is also present here as the group of pupils and the teacher analyse their lesson during the teacher and group pupil verbal protocol interviews, and the researchers analyse the same lesson using grounded theory methods. These five types of triangulation enhance the overall trustworthiness of the findings (Lincoln and Guba 1985). Different data sources (lesson, teacher verbal protocol, group pupil verbal protocol and group researcher interview) provide different perspectives on the data and different amounts of information. Table 2 below illustrates the number of times each element of the Pedagogy Analysis Framework was coded in total over all data sources.

We argue that it is valuable to have different researchers, including the teacher, in the project team. We coded the same data, in very different ways leading to different conclusions. For example, one of us (JPR) analysed pedagogy in minute detail leading to this paper, whilst another (MH) explored how a material-dialogic frame might inform transformation processes related to powerful knowledge and epistemic quality in the classroom (Hardman, Riordan and Hetherington (in press)), whilst the teacher (DC) without prompting used In Vivo coding (Bryant and Charmaz (2019)) in his analysis (before this study he was unaware of this research technique).

Disadvantages of multiple participants and methods include: considerable time needed for data analysis, huge amounts of data to manage, disagreement between participant interpretations, and conflicting theoretical approaches (Thurmond 2001). We acknowledge that the approach illustrated in this paper is laborious, but we may only need a few lessons, spread across a variety of subjects and age groups, analysed in this way to have a useful resource for Initial Teacher Education. Different interpretations of the same incident are possible. Another person coding the same passage may well interpret this in a different way (the foundations of symbolic interactionism are evident), but we argue that the Pedagogy Analysis Framework allows different interpretations of the same incidents to be understood, explained and evaluated and that this is useful.

Case studies like those included in this paper analysed using the Pedagogy Analysis Framework (Riordan, 2020) might help novice teachers, particularly those who struggle with their pedagogy, in understanding what experienced teachers do. Analysing complicated classroom interactions when time is available when doing research, or during university-based initial teacher education, or in an ITE student tutorial with a school-based mentor, is easier than managing such a complicated learning environment alone. Tactics are things that can be practised (unlike grand strategy), so a novice teacher could focus on improving a tactic in isolation before attempting to integrate this pedagogical skill into their practice. There are no simple answers to the challenge of learning how to teach, but the Pedagogy Analysis Framework might help (a claim to be tested in future research).

Researchers attempting to implement interventions do so into rich contexts dripping with strategies like the ones above. The noise and bustle of this classroom, where many participants are doing things simultaneously, is removed from the cleansed transcripts above. Reducing such complicated interactions to the key factors in the Pedagogy Analysis Framework may nevertheless be useful.

Originality

We argue, using the criteria for originality identified by Wellington (2012) that this study has the following innovative aspects. Firstly, a grounded theory study of pedagogy in school science lessons using the interpretivist theoretical perspective of symbolic interactionism and underpinned by a constructionist epistemology (social constructionism), would appear from our investigations to be new. Secondly, the pupil group verbal protocol interview was developed as a research method for this present study. Also, Taylor and Dionne (2000) claim that combining verbal protocols and retrospective debriefing interview data is 'uncommon' in the research literature. Therefore, the research method of combined lesson video-analysis with teacher verbal protocols, pupil group verbal protocols and retrospective debriefing constitutes an original approach. Thirdly, this study synthesises the findings of an earlier study involving six teachers working with small groups of pupils (Riordan, 2020) with this present one which used a naturalistic context (three whole class lessons). Finally, the Pedagogy Analysis Framework (a developing grounded theory of classroom pedagogy) and proposed Pedagogy Analysis Notation may be of use to teachers, teacher educators and educational researchers.

Limitations

In grounded theory, a substantive theory explains phenomena in one context. If substantive theory achieves 'theoretical saturation', a formal theory is possible which explains a phenomenon in a wider context (Glaser and Strauss 1967, 31). A previous study (Riordan, 2020) concluded that its inherent limitations meant it could only represent a substantive theory. The most significant limitations of that work were that pupil group verbal protocols were not included, the context studied was teacher-led small group work (termed expert microteaching) and teacher verbal protocols only used short video clips from the expert microteaching sessions as prompts. This present study addressed these limitations by investigating full lessons (a naturalistic context), introducing video-prompted pupil verbal protocol interviews, and teacher verbal protocols covered the whole of the lessons' video data. We argue that the present study has made significant progress towards becoming a formal theory, but that the following limitations of this present study mean that one further research project is necessary for the Pedagogy Analysis Framework to become a formal theory.

The most significant limitations remaining are as follows. Firstly, only one secondary teacher was involved in this work, so a future study should include several teachers teaching a variety of age groups. With the research design here, a large sample is neither necessary nor practical given the depth of analysis. Secondly, this present study involved only science lessons. Future work should include more than one subject discipline and the research team should include specialists in both subject areas. Thirdly, practical considerations meant the video data from this present study could not be made available in a secure repository for use in ITE, CPD and by other researchers. Allowing other researchers to explore this rich data set with similar and different research designs to question and challenge the interpretations presented here would bring further methodological triangulation and so be wise. Finally, some elements of the Pedagogy Analysis Framework were supported by considerable

evidence, but other parts remain tentative (see Figure 1), so it is not possible to claim theoretical saturation for all aspects of the theory. Hence the Pedagogy Analysis Framework remains a substantive theory with some aspects that may have wider applicability.

Other limitations of this research will now be outlined. The research methods cannot tell exactly what participants are thinking. Pupil verbal protocol interviews were not conducted with all pupils because of practical time constraints. The selection of clips for the group pupil verbal protocol interviews, done for pragmatic reasons, did pre-empt participants' choice of which sections are important. The time between the interviews may have influenced the findings. Interpretation of any incident in qualitative research like this has elements of subjectivity. Deception by participants, part of the Pedagogy Analysis Framework, necessarily has implications for the credibility of the findings. We acknowledge that as researchers we have influenced these data, though we sought to minimise this impact. Grounded theory methods were used carefully, but with so many codes and such a lot of video data, we acknowledge that some mistakes in coding are likely. This paper can only illustrate how the video-data supports the findings using a tiny proportion of the full data set (see the data availability statement below). Many technical challenges remain, particularly with recording good quality audio from noisy classrooms (boom microphones and table microphones may help). Similarities between some elements of the framework and the findings of other studies are acknowledged (for example, Wilson, Smith, and Ross 2003; Latour 2005).

Next steps

We argue the Pedagogy Analysis Framework (PAF), in its current form, is useful in understanding and explaining how participants operate in lessons. The next step will be to extend the PAF (over two future papers) to allow deeper analysis of why participants act. Given the argument earlier that pedagogy is concerned with interactions, the extended PAF will help clarify what exactly interacts and what the nature of this interaction is, permitting further analysis of the place of strategy within pedagogy. This next study synthesises a similar qualitative research design to the present one, with a large-scale quantitative design. Using a qualitative approach to structure the format of a subsequent quantitative tool is often seen as the best way to maximize the benefits of each methodological approach, which are otherwise often open to criticisms (Brannen 2005).

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