Becoming an expert teacher:  
Novice physics teachers’ development of conceptual and pedagogical knowledge  

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ABSTRACT: In this paper we report initial findings from a longitudinal study following the development in knowledge and expertise of beginner physics teachers in the first three years of their teaching experience. The focus of this paper and at this stage of our research programme is on the knowledge that beginning and expert physics teachers exhibit when responding to physics questions set in a pedagogical context. Furthermore, we present a conceptual framework for characterising the professional development of science teachers. The analysis shows that it is indeed pedagogic reasoning, rather than conceptual understanding, that marks the difference between beginner and expert teachers in our sample.

Introduction

In this paper we report initial findings from a longitudinal study following the development in knowledge and expertise of beginner physics teachers in the first three years of their teaching experience. Our study also compares the knowledge and practice of these developing teachers with that of expert physics teachers. The overall aim of this study is to identify in detail aspects of teacher knowledge and expertise that characterise the development of physics teachers as they progress through training courses and the early years of professional practice in schools. The focus of this paper is on the knowledge that beginning and expert physics teachers exhibit when responding to physics questions set in a pedagogical context.

A range of studies has provided insights about how student teachers and beginner teachers first encounter teaching and their ability to reflect on practical experience (Penso, Shoman, & Shiloah, 2001), how science teachers’ beliefs about science and science teaching influence classroom practice (Brickhouse & Bodner, 1992) and how induction programs are essential in addressing the pedagogical and content needs of science teachers (Luft, Roehrig, & Patterson, 2003). Furthermore there are studies of prospective science teachers’ beliefs concerning constructivist teaching practice (Haney & McArthur, 2002) and studies of beginner teachers’ and experienced teachers’ conceptions of the concept of prior knowledge (Meyer, 2004). There are also studies which have examined the differences between expert and novice teachers (Hogan, Rabinowitz, & Craven, 2003) and the professional development of beginner teachers (Kagan, 1992). However, there have been few studies following teacher trainees through their initial training and into the first years of classroom teaching. One exception is provided by Calderhead & Shorrock (1997) who followed student teachers during their professional training and in some cases into their first year of teaching in schools. All of these students were training to become primary teachers and their teacher training focused largely on the primary school curriculum with its wide range of subjects. This research, however, dealt with general classroom management and managing activities. In our study we focus on teaching and learning specific topics in physics.

Model of development of expertise in science teaching

We have found it helpful to conceptualise our research programme in terms of a framework for characterising the development of expertise of science teachers. In our
study this framework supports the development of case studies of individual teachers which are designed to investigate the interaction of the differing aspects of professional practice in particular physics teaching contexts over an extended period of time. The framework relates to three aspects of practice: knowledge base, pedagogical action and fundamental influences. A similar approach is taken by Clark and Peterson (1998) in their ‘model of teacher thought and action’, whilst Clark and Hollingsworth (2002) place “the pedagogy of teachers” at the heart of their model for teacher professional growth. They suggest that “…(the) structure of the model provides recognition of the situated and personal nature, not just of teacher practice, but of teacher growth: that amalgam of practice, meanings and context” (p. 965).

Although there are inevitable similarities with approaches taken by other researchers in this field of enquiry, one novel (and central) feature of our framework is the identification of the communicative approach (Mortimer and Scott, 2003) as a key element in the development of pedagogical action from novice to expert science teacher.

![Diagram](https://via.placeholder.com/150)

**Figure 1. Framework: aspects of development of teacher expertise**

We believe that pedagogical action is intimately related to the kinds of knowledge (about content, teaching strategies, pupils reasoning etc), or knowledge base, which are available to novice and expert science teachers. For example, we would expect beginner teachers typically to have some understanding of science
content, but to have rather less knowledge of teaching strategies which might be used to teach that knowledge. Conversely, expert science teachers might be expected to have a more integrated knowledge base where connections are made between specific aspects of science knowledge, teaching strategies to teach that knowledge and the related students’ reasoning. Thus for the beginner teacher there is a tendency to focus on their own teaching performance (Hogan et al., 2003) and to be primarily concerned with the transmission of correct information or content. In this way, it might be expected that the beginner teacher adopts a communicative approach (Mortimer & Scott, 2003) which is largely authoritative in nature. By way of contrast we conceptualise the practice of the expert as focussing on both teaching and learning and being concerned with responding to the learner’s existing situation as they introduce the science point of view (Hogan et al., 2003; Meyer, 2004; Shulman, 1986, 1987, 2000). The expert is able to move fluently between authoritative (making the scientific view available) and dialogic passages (taking account of students’ reasoning) of teaching (Mortimer & Scott, 2003). In other words, the expert science teacher is likely to demonstrate both authoritative and dialogic communicative approaches in their teaching according to the teaching context and purposes.

The knowledge base presented in the framework includes subject content knowledge, curriculum knowledge, pupils’ reasoning and teaching strategies and as such relates closely to Shulman’s categories incorporating subject content knowledge, curriculum knowledge, knowledge of learners and their characteristics and including pedagogical content knowledge, PCK (Shulman, 1986, 1987, 2000). Shulman (1987) defines PCK as follows:

...pedagogical content knowledge is of special interest because it identifies the distinctive bodies of knowledge for teaching. It represents the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organised, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction. Pedagogical content knowledge is the category most likely to distinguish the understanding of the content specialist from that of the pedagogue (p.8).

Various scholars have further developed conceptualisations of PCK (see e.g. Gess-Newsome & Lederman, 1999). PCK has, however, become an accepted academic construct focusing on teachers’ approach to teaching particular content (Loughran, Mullhall, & Berry, 2004).

Not surprisingly, there are similarities with the knowledge base presented in our framework and that of other researchers. For example, Barnett and Hodson (2001) have examined teacher knowledge development from novice to expert and identify teacher knowledge as including: classroom knowledge (e.g. knowledge of students), professional knowledge, academic and research knowledge (e.g. knowledge of science and nature of science, knowledge of how students learn) and pedagogical content knowledge. Furthermore, studies relating to teaching about the nature of science (Brickhouse, 1990) have shown how teacher knowledge is not necessarily enacted in the classroom due to constraints such as managing pupil behaviour and external assessment requirements. A study by Mellado (1998) focused on the difference between pre-service teachers’ conceptions about teaching and learning science and their classroom behaviour.

There is a wide literature that addresses the novice – expert transition. For example; (Dreyfus & Dreyfus, 1986, 1991) describe a five step process: novice to
advanced beginner to competence to proficiency to expert. The stages can be related to teaching e.g. adapting rules to account for the context, acting with a specific goal in mind, recognising several key features in a situation (rather than focusing on only one). This model is discussed in the context of teaching by Olson (1992). In the review by Kagan (1992) several ‘stage models’ of teacher development are mentioned, and she suggests that professional growth involves at least five components: increase in metacognition; knowledge about pupils; shift in attention from self to pupil; development of standard procedures; and growth in problem solving skills. Furthermore, Calderhead and Shorrock (1997) argue that studies of the professional growth of teachers have tended to cluster around five particular models that emphasise specific aspects of learning to teach, and that construe the learning process in characteristic way. These include: models of socialisation into the professional culture; knowledge and skills; a moral endeavour; relations between personal and professional development; and models of reflection. Some important differences between expert-novice teachers in subject teaching are also identified by Hogan et al. (2003) who found that experts plan teaching over a longer term and include more strategies than novices. Furthermore, experts make more transitions between activities, provide alternative explanations and focus on individual achievement rather than the interest level of the class.

We recognise that the development of pedagogical practices and the related knowledge base are influenced by a number of extrinsic (contextual) and intrinsic (belief) factors. The *extrinsic* factors might, for example, include the prevailing ethos and approaches to teaching of a particular school science department. Put briefly, if the teaching a school science department is traditionally transmissive in approach, then it will be all the more difficult for a beginner teacher to develop a more responsive teaching style. One *intrinsic* factor might be the beginner teacher’s view of the role of the teacher. If this view is, for example, based on ‘getting the information across’, then the beginner teacher is unlikely to spend much time in probing students’ understandings in a dialogic approach. Kagan (1992) argues along similar lines in pointing to beginner teachers’ beliefs about classrooms and images of themselves as teachers (an intrinsic factor), and that these prior beliefs are associated with their own experience in classroom and relationships with teachers. These personal beliefs follow trainees into classroom practice, and for professional growth to occur prior beliefs and images must be modified and reconstructed.

In this paper and at this stage of our research programme, we are focusing on a restricted part of the framework. In particular we are exploring the knowledge base for novices and expert teachers respectively. Thus we present data from this first phase of our study and examine beginner and expert teachers’ written responses to science questions set in specific pedagogical contexts. As pointed out in the model, the focus is on the differences between the ability of novices and experts to draw on the knowledge base, and particularly how they refer to pupil reasoning, teaching strategies, subject content knowledge and curriculum knowledge. Specifically, we address the following research questions:

- What are the key features of the knowledge bases (relating to content, teaching strategies, pupils reasoning) which beginner and expert teachers draw upon when responding to teaching or pedagogical contextualised science questions?
- What are the key differences in those knowledge bases?
In the next phase of the project we will develop detailed case studies in order to study how context and beliefs in addition to the knowledge base relate to the development of pedagogical practices (conceptualised in terms of communicative approach) over time.

**Methods and Sample**

A written questionnaire containing eight items was used to probe respondents’ thinking about content and pedagogical issues within a range of physics content areas. The questions were designed to shed light on how the respondents would express their content knowledge in a pedagogical context. For example how they referred to possible misconceptions, the pupil’s possible prior knowledge or how they sequenced their answers. The questions are however, focusing on to some extent different aspects, and for the analysis in this paper we have chosen the four questions which most purposely aim at investigating the respondents’ content knowledge set in a pedagogical context. Aggregated data from these four questions will be analysed along with analyses of data from two individual questions. The two questions not discussed in detail are shown in the appendix. A Working document showing preliminary analyses of all the eight questions can be found at: [http://www.education.leeds.ac.uk/research/cssme/workingdoc.pdf](http://www.education.leeds.ac.uk/research/cssme/workingdoc.pdf).

A total of 41 trainee physics teachers from six universities in the UK completed the questionnaire. 24 of these teachers had a strong physics background (typically a physics degree). By contrast 17 of these teachers had completed degrees with more limited physics content but had attended an innovative six month course to enhance their physics content knowledge before beginning their teacher training course (further details of this course are available at [http://www.gatsby.org.uk](http://www.gatsby.org.uk)). Sixteen expert physics teachers also completed the questionnaire. These expert teachers all had at least three years teaching experience and were known to the authors as exemplary teachers of physics. Responses were categorised and coded inductively. Reliability was checked by independent coding of responses by the researchers. This resulted in more than 80% overall coding agreement. The responses were then reread several times and interpretations were modified and refined during intensive discussions. The final categorising and coding were then based on these common interpretations. And moreover, all the respondents have as far as we can conclude answered the questions seriously.

We recognise that probing teachers’ pedagogical content knowledge is a complex task (Loughran et al., 2004). In the broader context of our study, analysis of written responses is used as a starting point for a more detailed analysis of teacher expertise that draws upon classroom observations and post-lesson teacher interviews.

Ours is not a questionnaire survey where random samples from two different populations are compared. Statistical significance testing based on a known sampling distribution is therefore not applicable. However, nonparametric methods can be used when nothing is known about the parameters of the variables of interest. Nonparametric significance testing does not rely on the estimation of parameters describing the distribution (e.g. the normal distribution) of the variables. In the analyses we have used Mann-Whitney U significance test for individual questions as well as for aggregated data across the four questions. The p-value (asymptotic significance) is shown in brackets where applicable.
Data analysis and results from the questionnaire survey

All the responses were categorised and all the variables were put into one of two broader categories; “content” or “pedagogy”. In the following diagrams results for individual variables are shown. The bars in these diagrams represent the percentage of each group (students and teachers) who have given a valid response for each of the variables (coded categories). Many responses could be coded into more than one category. Some categories have very few responses and are omitted from the figures, with comments in the text if appropriate. Figures showing the mean of the total number of responses for content and pedagogy respectively are also shown. One point is given for each correct/valid content variable and for each productive/valid pedagogical variable. Zero points are given for incorrect and unproductive responses.

Ball in the air

You are teaching mechanics to a Year 10 class. One of the pupils, John, argues that the forces acting on a ball, when it is thrown up in the air, are as follows (the diagram shows the ball after it has been thrown).

![Diagram of forces acting on a ball](image)

John says:

‘When you throw the ball up, it sets off with a BIG upward force but this gradually runs out and gets less, so that at the top the upward force is balanced by gravity and the ball stops going up. The ball then falls because of the pull of gravity’.

a. Do you think that John is correct in what he says?

b. What would you (the teacher) say in reply to John?

This was the first item in the questionnaire, and John is expressing the very common misconception that there must always be a force in direction of motion. It is known from a large number of studies that this sort of problem is very difficult for many pupils (Angell, 2004; Duit, 2004; Viennot, 2001). In this study, however, we were primarily interested in how the beginning teachers and the expert teachers responded to the problem in this “authentic” teaching context.

Most of both students and expert teachers answered no to the first question. There are however, 10 students (but no experts) who wrote that John is almost correct or that it is something correct in what he says; for example that the ball falls because of the pull of gravity. Some misconceptions were also revealed as this answer from one of the students illustrates:

Yes, he understands that the forces are balanced at the peak.
However, relatively few misconceptions were exposed and it appears not to be a significant problem within our sample.

The result of the second question is presented in Figure 2 and Figure 3. As shown in the figures, the biggest differences between the students and the teachers were related to pedagogic knowledge rather than conceptual reasoning. The expert teachers were significantly more likely to reply with a question and to challenge students’ conceptions (Mann-Whitney U test; \( p < 0.05 \)).

![Figure 2](image_url)

**Figure 2.** The figure shows the prevalence of different content categories from students and expert teachers respectively.

Generally the expert teachers provided a logical pedagogical sequence in their responses more extensively than the students. However, for this particular question some of the students also provided some logical sequencing. Moreover, only two expert teachers, and none of the students, mentioned everyday thinking or typical alternative conceptions in their responses. One of these two experts wrote:

(...) *This student is confusing the ideas of velocity and force and coming up with a “combined” idea. In this case it is necessary to try to separate the two concepts in the student’s mind.*
Many of both the teachers and the students referred not surprisingly to gravity as the only force acting and that an upwards force was only acting when the ball was in contact with the thrower’s hand. The subject knowledge seemed to be very good within both groups, and few respondents exposed the misconception of a force in the direction of motion when the ball is moving upwards. The teachers were also more likely to refer to acceleration and change in velocity. Very few respondents referred to momentum, energy or for example the effect of air resistance.

The following is a quotation from a student who gave an excellent response focusing on the content knowledge.

You apply a big upward force when you let go. Once you let go there is only one force acting downwards on the ball and that is gravity. The initial throw gives the ball upward movement. Gravity is opposing the movement, so it slows down, stop, then speed up as it falls back to earth.

The following expert teacher explicitly challenged the pupil’s view and the quotation is a good example of how an expert uses his or her pedagogical experience along with the content knowledge and provides some logical sequencing:

I would tell him he was partly correct – and that his explanation of why the ball fell was right. I would ask him what applies the upward force after the ball leaves the thrower’s hand? – Mechanical forces need contact to apply them. Hopefully he would realise that there could not be an upward force. I would then use his own explanation of why the ball fell (i.e. gravity) in conjunction with Newton’s 1st law to explain why the ball slowed down AND why it left the thrower’s hand with an upwards velocity.
Some of the students also took pedagogical considerations into account by replying with questions as the following citation illustrates:

*When you let go of the ball at the end of your throw are you still applying a force? Where can the big upward force come from? If you think about unbalanced forces – the ball must slow down + start falling because of the action of gravity.*

Even though the overall analysis of the respondents’ conceptual understanding revealed very few misconceptions, a small proportion of the students demonstrated some misconceptions as the following citation illustrates:

*As the ball increases in height the amount of gravitational potential energy it possesses increases. Eventually this equals the upward force and the ball is stationary.*

Figure 4 shows the calculated means of the sums for valid responses coded as content and pedagogy respectively.

![Graph showing mean of total number of responses for content and pedagogy from students and expert teachers](image)

**Figure 4.** The figure shows the mean of the total number of responses for content and pedagogy from students and expert teachers respectively.

There were seven valid content and eight valid pedagogical categories. The expert teachers put notably more pedagogical considerations into their responses, whilst the number of content arguments is quite similar for both groups. The Mann-Whitney U test showed that for the category “pedagogy” there was a statistical significant difference between the two groups \( p < 0.05 \), but not for the “content” category. On average each expert gave 1.6 pedagogical arguments compared to 0.4 for each trainee.

As mentioned above, much research in science education has focused on students’ conceptions of force and motion and the nature of possible misconceptions. This is a challenge for all teachers. However, our data indicate that novice teachers to much less extent than the experts take pedagogical considerations into account when
they are thinking of how they will respond to a typical misconception like the one John express. Some experts did not focus at the content at all and provided only some pedagogical suggestions as the following illustrates:

Get him to name the upward force, describe its origin (he would say “the hand”). Ask why it gets less (he would argue about air resistance). Remind about un/balanced forces. Then if he says “hand” ask what is still producing force when not in contact with hand. How long does it take to wear off? This sort of questions makes John’s simple explanation start to look rather complex.

The key point here is that for this experienced teacher it is obvious what the correct physics is. Therefore the response to John is described in terms of pedagogical reflections. The teacher is focussing on both teaching and learning and is concerned about the learner’s situation. The quotes from the both two experienced teacher here point to their ability to move between authoritative and dialogic passage of teaching (Mortimer & Scott, 2003).

In the dark

This item deals with the fact that both humans’ and cats’ eyes must receive light in order to see. Ann in this task expresses the common misconception that cats’ eyes are “active” in the sense that cats can see independent of incoming light (Galili & Hazan, 2000; Viennot, 2001). Here the trainees and the teachers were asked what they would do in class in the described situation.

You are teaching a lesson about light and seeing to a year 7 class. One of the pupils, Ann, puts her hand up and says:

‘Yes, but my cat can see in the dark!’

What would you do in class to persuade Ann that neither cats nor humans can see in the dark?

The same pattern emerges from Figure 5 as it did for the previous task. In particular the differences between the teachers and the students were noteworthy for proposed activities (both dark room activity and other activities) and for productive discussions (Mann-Whitney U test; \( p < 0.05 \)). The expert teachers also provided a more extensively logical pedagogical sequence in their responses indicating where they would wish to start and how they would proceed from here towards an appropriate understanding (Mann-Whitney U test; \( p < 0.05 \)). What also emerges from the data are the expert teachers’ comprehensive suggestions for discussions. Some student teachers also made suggestions for discussion, but generally they tended to focus more on what they would tell their pupils in a more authoritative, rather than dialogic way.

Most of both trainees and teachers conveyed a correct understanding of the physics involved in the task; emphasising that the eye must receive light in order to see or that dark means no light at all.
The question was what you would do in class to persuade Ann, but many students did not propose activities as the following response illustrates:

That’s not true. Cats are better at seeing at low light levels. Even at night there is light, some stars, the moon and the street lights. If there was no light at all then your cat would not be able to see at all.

Someone was also focusing on the cats’ uniqueness or that cats can see in lower light levels as the following two quotations from students show:

(…) Explain that cats have evolved advanced methods for getting around in the dark including whiskers and acute smell.

Explain that cats can see better than humans, i.e. in lower light levels, but that light still has to bounce off an object for it to be seen. (…).

The following quotation is the start of an extensive response from an expert teacher who relates the answer to basic physics combined with an activity. The response is also an example of what we would categorise as logical sequencing.

I would restate the idea that both human and animals see by reflection of light and so in order to see we need some light. Following this I would draw a distinction between dark (low light level) and blackout (complete absence of light). If possible I would then use a blackout in the lab to show that you cannot see objects if there is no light.
Another expert emphasised both experience (activities) and discussions as the next quote illustrates:

**Experience** – we do have a store room without windows, sealed door etc. so they can (small groups) experience total darkness.

**Discussion** – how eyes work, plus develop idea of reflection – darkened classroom, use road traffic items (...) with torch/projector shone on them – discuss again, what if no light source etc.

Figure 6. The figure shows the mean of the total number of responses for content and pedagogy from students and expert teachers respectively.

Figure 6 shows again that even though they were explicitly asked to do so, the trainees were significantly less likely to give answers related to pedagogical reasoning than the experienced teachers (Mann-Whitney U test: $p < 0.05$). On average each expert gave 2.8 valid pedagogical arguments whilst each trainee gave 1.3.

**Total sums of content and pedagogy**

In order to provide an overall image of the responses from the expert teachers and the trainees we have computed the total sums of content and pedagogy for the four selected questions (see Figure 7). Indeed, what primarily characterises an expert teacher compared to the novices is that the expert uses pedagogical arguments more extensively in his or her responses. On average each expert gave 7.7 pedagogical arguments in total compared to 2.5 for each trainee. The same pattern emerges when we look at the answers to all the eight questions in the questionnaire. On average each expert teacher gave 16.3 pedagogical arguments whereas each trainee gave 7.4.
As previously mentioned, we also compared the responses of trainee teachers without a subject specialism in physics with those of trainees with specialist physics backgrounds. These science graduates without background in physics have been through a six months extensive course in physics (the Physics Enhancement Programme, see http://www.gatsby.org.uk) preparing them for teaching physics up to and including Advanced level (specialist course for pupils aged 16 – 19). There appeared to be very small differences between the two groups of students when looking at individual items and the overall impression is the same. There are significant similarities between the two student groups for both content and pedagogy (Angell, Ryder, & Scott, 2005).

**More about pedagogical knowledge**

Figure 8 shows four aggregated variables from across the four questions. The categories “logical sequencing” and “reference to alternative conceptions” are found in all four questions and “reply with question(s)” and “challenging student’s response” in three questions. The bars represent the percentage of those within each group who have been coded at least once into the category. For example very few of the students gave any references to alternative conceptions whilst 38 % of the experts did so. This is in accordance with Meyer (2004) who found that novice teachers hold limited conceptions of prior knowledge and its role in instruction while expert teachers hold a complex conception of prior knowledge and make use of their students’ prior knowledge in significant ways. Furthermore, there are nine (56 %) expert teachers, but only two students (5 %) who have given answers categorised as “analysis and/or challenge of students’ responses” if we look at this category across the four questions. The difference between the experts and the trainees was also significant for the variable “reply with questions”; 62 % and 39 % respectively. Again we might conclude that experienced teachers use their pedagogical knowledge to a substantially greater extent than novices.
Figure 8. The figure shows the occurrence of four different categories from across the questionnaire. All the differences between the two groups are significant according to Mann-Whitney U test ($p < 0.05$).

One might argue that providing a logical pedagogical sequence in their responses is an essential characteristic for an expert teacher. Figure 8 also shows substantial difference for the two groups’ responses. 87% of the experts and 37% of the trainees have been coded for logical sequencing at least once across the four questions.

Figure 9. The figure shows the distribution of responses categorised as logical sequencing.
Figure 9 shows in detail the distribution of responses for this category, and the figure shows that the experts are likely to give responses showing logical sequencing more than once.

**Conclusions**

We have shown that our sample of expert teachers is more likely than the novice teachers in our study to refer to pedagogic issues in response to written questions about science content set in a school teaching context. Indeed, it is pedagogic reasoning, rather than conceptual understanding, that marks the difference between beginner and expert teachers in our sample. Furthermore, there appeared to be insignificant differences between the trainee teachers with and without a subject specialism in physics for both content and pedagogy in our sample.

The following list is a summary of the ways in which expert teachers exhibited pedagogic reasoning in their responses:

- listing questions they would ask in the classroom;
- explicitly challenging a pupil’s view;
- addressing pupils’ everyday thinking;
- referring to pupils’ prior learning experiences;
- suggesting possible class activities and/or discussions;
- suggesting teaching analogies that would help to explain the concept;
- providing a logical pedagogical sequence in their responses;

Our data reflect the difference between personal understanding of a topic and understanding what is required for someone else to know and understand it (Shulman, 2000). As already mentioned, the trainees’ content knowledge and their understanding of the physics involved in the questions appeared to be quite good. However, teachers also communicate a set of attitudes and values that influence pupils’ understanding. This responsibility places special demands on the teachers’ own depth of understanding of the structure of the subject matter, as well as on the teachers’ attitudes towards, and enthusiasm for, what is being taught and learned.

*But the key to distinguishing the knowledge base of teaching lies at the intersection of content and pedagogy, in the capacity of a teacher to transform the content knowledge he or she possesses into forms that are pedagogical powerful and yet adaptive to the variations in ability and background presented by the students* (Shulman, 1987).

Looking at the list above, the expert teacher is portrayed by a wide range of knowledge. Moreover, the categories referred also fit quite well into Shulman’s “model of pedagogical reasoning and action”. What actually characterises an expert teacher is how she or he can move from personal comprehension to preparing for the comprehension of others, how she or he is able to use multiple forms of representation, e.g. analogies, metaphors, activities, demonstrations etc., how she or he makes links to pupils’ preconceptions or misconceptions and other pupil characteristics and her or his ability to move between authoritative and dialogic passage of teaching (Mortimer & Scott, 2003).

The comparative analysis with expert teachers’ responses has enabled us to identify in some detail the range of pedagogic understandings that these novice teachers will need to develop during their training. Our findings point to the need to
create new ways and opportunities for the development of pedagogical thinking among novice teachers. Indeed critical pedagogical reflection about teaching and learning has to be seen as an integral part of the teachers’ professional development (Penso et al., 2001).

By analysing responses to the questionnaire we have elucidated some major features of our framework. The beginner teachers tend to be primarily concerned with the transmission of correct content, and they tend to draw on discrete elements of knowledge. By contrast, the expert teachers made more extensive links between their knowledge within different contexts. As illuminated in the framework, it seems that the pedagogical reasoning of the expert teachers is much more focused on both teaching and learning and being concerned with responding to the learners’ existing situation as they give answers to the questions in the questionnaire. In other words, our data reflect our conceptual framework focusing on the shift from novice to expert in terms of a shift in pedagogical thinking and practise, i.e. a shift from restricted, transmissive and authoritative practice to more expanded, interactive and dialogic practice.

What are the implications of our findings for practice? At least for the beginning teachers in our sample knowledge of pupils’ reasoning, teaching strategies and curriculum knowledge, rather than subject knowledge, represent the key deficiencies in their knowledge base. Questions of the kind presented in this paper could be used at the beginning of initial teacher training courses as a way of auditing the needs of students with subsequent teaching activities tailored to address key knowledge deficiencies. We have also identified seven characteristics of the responses of our sample of expert teachers to physics questions set in a pedagogical context. Explicitly presenting these characteristics to beginner teachers, and exemplifying them, may support their thinking about pedagogical issues related to specific content areas in physics.

This paper presents initial findings from our study with a focus on the knowledge base of expert and novice physics teachers. Future work will address the development of this knowledge base as these teachers continue their professional development in their first teaching posts. In addition we will use case studies to examine the relationship between this knowledge base and teacher action, with a particular focus on communicative approaches used by these teachers in the classroom. Using case studies will also enable us to examine the influence of both intrinsic and extrinsic factors on teacher development in the early years of their teaching experience.

Bibliography


Appendix

Skater (item v2)
You are planning a top-set Year 11 revision lesson about forces. In the science staffroom you find an OHT showing a skater gliding across an ice rink. The skater has just pushed-off and is very gradually slowly down.

a. On the picture above show how you would draw the forces acting on the skater when using the diagram in the classroom.

Mary, one of your pupils, says:

‘As long as the skater is moving forwards there must be a force pulling her - that’s for certain!’

b. How would you respond to Mary?

Series circuit (item v6)
You are teaching a bright Year 10 class about electric circuits. You go through the basic ideas of charge, current and energy transfer and they seem to have no problems with your explanation of how a simple one battery/one bulb circuit works.

In the next lesson the focus is on series circuits.

What, do you think, are the key points which you will need to emphasise to pupils as you move from the single battery/bulb circuit to presenting an explanation of how a series circuit (one battery and two bulbs) works?