Exploring the Pedagogical Reasoning of a Physics Teacher Educator

Dario Alberto Maringer Duran

B Sc, B Ed

Submitted in partial fulfilment of the requirements for the degree of Master of Education

Faculty of Education, Monash University

Melbourne, Australia

June 2014

Declaration

This project contains no materials which has been accepted for the award of any other degree or diploma in any university and, to the best of my knowledge and belief it contains no materials previously published or written by another person except where due to reference is made in the text of the thesis.

Signed:…………………………………

The research for this project received the approval of the Monash University Standing Committee for Ethical Research in Humans.

Project 13/2117 – 2013001102

Acknowledgment

The number of people who played a role in giving me enough momentum to go into the hard work of teaching is countless; for all of them I extend my gratitude because it is, without a doubt, one of the most rewarding careers.

To my sons, Matias and Ariel, to my daughter Valentina, and to my soul mate Cecilia thank you for sharing your lives with me; do not ever forget that I love you.

To my dear companion in the last five years, Rolando Adan Diaz Delgado a totally amazing teacher educator.

I am really grateful for the editorial assistance received from my friend Max Kauffman and my supervisor Dr Adam Bertram. They not just helped me to build the bridge between my own English and the English needed to complete this journey, but they introduced me into other ways to express ideas. Thanks to both.

To my participants, the Physics Teacher Educator and his student teachers, thanks for allowing me to take part in your class, and also for giving me your time patiently. Thank you to all concerned.

To my supervisors, Dr Adam Bertram and Dr Hongming Ma, thanks a lot for your kindness and friendly support. Finally, I would like to express my gratitude to Dr Adam Bertram. Adam, I really appreciated all of your insightful comments and advice. I valued them because at no time did I feel lost in my research because of your guidance throughout. You were remarkable.

Table of Contents

List of Tables

List of Figures

List of Appendices

Abstract

The education literature reviewed recognises a preponderant role played by teacher educators in preparing student teachers for classrooms. However, it also recognises that not so much is known about how teacher educators express and represent their pedagogy. The study used an interpretative phenomenological analysis method to investigate what is important to science teacher educators when teaching how to teach, why that is relevant and how they know it.

The study was focused on the pedagogical reasoning (PR) of a physics teacher educator; how he perceives and expresses it pre, during and post teaching in a physics discipline unit in a graduate teaching program. How his pedagogical reasoning is perceived by his student teachers and to what extent it is connected with their learning experience. Shulman's model of pedagogical reasoning and actions was used as a lens to observe this physics teacher educator's PR including his perceptions and beliefs around teaching. Mostly through semi-structured interviews and teaching observations, the teacher educator's PR and thinking behind his practice were explored. Student-teachers provided feedback on their views of their teacher-educator's PR, their choice of pedagogy and whether this might have influence in their own developing pedagogies.

The research arrived at two significant findings. The first one is that the teacher educator's beliefs and views about what physics and teaching physics is about shaped and guided his pedagogical reasoning. For the teacher educator, physics and teaching physics is about "doing" things and explaining or attempting to explain a concept, a phenomenon or an experience. The second finding makes visible the key role that student teachers' feedback had on the teacher educator's PR. It was seen that his PR was never static but was constantly evolving due to constant evaluations of his practice and his student feedback. Discussions with the student teachers also showed that

through exploring their teacher educator’s PR, that they themselves also thought more deeply about their own practice in ways they felt gave them a greater understanding in approaching and developing their own PR. By exploring the PR of an expert teacher educator, the crucial role of teacher educator can be seen as critical in the development of student teachers for the classroom.

1. Introduction.

This chapter presents the study and its rationale. Firstly it explores the justification of why this research might be important in science educational research. It introduces the concept of pedagogical reasoning (PR) and then specifically introduces the role a TE plays in reducing the gap between what is known about teaching and learning and how student teachers (STs) connect those theories with their practice. The chapter concludes by presenting an outline of the thesis' structure.

1.1 Introducing Pedagogical Reasoning

One might argue that the act of planning for teaching is an action that might only occur prior to a teaching episode, or prior to teaching a new topic. Similarly, a fair assumption might be that the process of reflection or evaluation of the teaching episode occurs after such event. However, during each class, a significant number of expected and unexpected events might impact and alter the original teaching plan and the pedagogical approaches utilised. Those events could trigger immediate reflection and evaluation *during* the teaching episode. The teacher might develop new ideas that change the direction in a particular learning moment. Or they may keep in mind this new idea/approach for another occasion.

There are a number of triggers during the class that might make the teacher divert from their original plan. This could be due to students' questions, arguments or comments that have arisen, or discovering students' previous experiences or knowledge which may make some activities redundant while others more important. Expert teachers can perceive where the direction of a teaching episode might likely go and by using their "wisdom of practice"(Shulman, 1987, p. 11) they alter the direction of the discussion and/or change their teaching actions accordingly. In other situations, particular unexpected events might occur in class and the teacher accommodates this into their lesson plan immediately. Some experienced teachers also reflect on classes recently taught and look for ways to improve those lessons for the future. In attempting to improve their practice, and support a meaningful learning environment, usually these experienced teachers are involved in decision-making situations. These decisions are difficult for TE's to actually explain (John, 2002; Nielsen, Triggs, Clarke, & Collins, 2010). Observation of how these teachers act in practice can also reflect how they think about their practice (Loughran, 2010). There is a rationale behind their practice. Each class, or teaching period, represents an opportunity where they may introduce new ways of comprehension, update their teaching plan and include different teaching strategies to teach and to get feedback from their students. It is relevant to know what was done successfully, and what needed change. Reflection is important to teachers in evaluating their teaching. It is also very important to know what those students understood, and what they learnt in an ongoing manner. In this way, expert teachers follow a constant cycle in planning, teaching, evaluating and reflecting many times over in a single teaching episode.

The present study is focused on capturing and portraying the pedagogical reasoning (the why and how) of an experienced TE. The study aims to gain insight into why and how they make particular pedagogical choices when teaching particular content and how they support their STs in developing their own pedagogical reasoning (PR). The study explores the idea that experienced TEs' own pedagogical reasoning may be modelled, observed and influential to their own STs in developing effectively their PR, and, in this way, helping STs to better understand their own practice. From this standpoint, if we carefully observed expert TEs in action, then their rationale and explanations of their actions and thoughts might help to improve other TEs' and STs' pedagogy. While some teachers attempt to follow the original schedule without deviation; others might be sensitive to events and episodes within the classroom environment, and as a consequence, change their teaching plans, not just once, but many times. Nevertheless, not all changes might be successful. Teachers' "wisdom of practice" (Shulman, 1987, p. 11) can therefore be shaped by experience within their daily practice. That experience could lead, in some cases, to improve students' learning. Exploring how expert teachers reasoning before, during and after a teaching period might offer the opportunity to analyse effective lessons and how they might approach problematic events/episodes. Exploring the "pedagogical reasoning and actions" (Shulman, 1987, p. 5) behind why an expert TE did what they did might offer a new understanding in improving TEs' pedagogical practice and help to improve their pedagogy.

1.2 The Role of a Teacher Educator

Darling-Hammond (2006) claimed that the programs that best supported teacher preparation were those that approached teaching as "learning–centered" (p. 7) and "learner-centered" (p. 8). These programs were also concerned with reducing the gap between coursework and practice work so, consequently, they have been reducing the gap between theory and practice. All of these programs include TEs' efforts to be congruent within their practice because that represents, in pedagogical actions, the teacher education program's aims. Learning about teaching and learning comes from actual experience when they enter the profession, (and that which constitutes what STs might also experience on practicum) but it is also supplemented with learning about teaching and learning in their teacher-education programs (Berry & Van Driel, 2013; Darling-Hammond, 2006; Lunenberg, Korthagen, & Swennen, 2007). In short, TEs may contribute more to their STs' PR if they act as a role model and explicitly reveal their own PR in their practice (Lunenberg et al., 2007).

Research has shown that TEs do play a significant role in preparing STs for the classroom (see Berry & Van Driel, 2013; Jasman & McIlveen, 2011; Peterson & Treagust, 1995; Shulman, 1987). TEs are recognised as a serious and important part in the professional development of beginning teachers. However, not so much is known about how they interpret and process their own teaching experience and, consequently, how this is manifested in their practice and pedagogy (Berry & Van Driel, 2013). For instance, it is common that within teacher education programs, TEs usually design their courses and units guided by their own knowledge, experience and development of their own skills within their practice. However, usually they do not explicitly draw on their pedagogy or reveal their knowledge in teaching to teach, generally not because of modesty, but because they operate at an unconscious level (Berry, 2009). In consequence, how does a TE construct their teaching plan and then develop it during their teaching? And how does a TE know what is worthy or relevant and what is not during each class? These questions still need more research. In order to construct an effective pedagogy of teaching, it is important to explore the pedagogical reasoning (PR) of experienced TEs. They, as once former beginning teachers themselves, are possibly a key factor and might be an influence in the development of quality teaching and PR in their STs. Therefore, a TE who is cognisant of their own PR may be more effective in preparing their STs for the classroom.

1.3 Transition from Student to Teacher

Transitioning from the role of "student" to that of "teacher" can be hard work. Often, STs picture that teaching would be less difficult than it really is (this is usually based on their long and personal experience within primary and secondary school) (Darling-Hammond, 2006; Shulman, 1987). STs commence their graduate or undergraduate programs with personal experiences about what teaching is and how an expert teacher might teach. They can argue or explain how expertise of teaching could be mastered. For instance, Chastko (1993) explained that some STs think that becoming a teacher is just a matter of gaining some teaching experience. However, it is not that simple. Darling-Hammond (2006) explains the "new mission for teaching" (p. 9) underlining that teachers have to be cognisant in addressing students' needs to be active participants in the actual world. In trying to address that goal, experienced and expert teachers may have problems when explaining what “good teaching” means or what it looks like. Nielsen et al. (2010) conducted a study that explored how mentor teachers could better help STs during their practicum. There were a considerable number of beliefs, held by this group of mentor teachers, but they were not clear enough, neither about their role, nor about how they could support their STs and explain to them their own pedagogy. They experienced a highly conflictive and complex situation in mentoring their STs. Mentor teachers finally concluded that they cannot deal with all their issues. They understood that STs’ practicum experience has its own limitations (Nielsen et al., 2010). Teaching to teach includes learning how to teach and comprehending how students learn particular concepts. It is not as simple as transmitting knowledge to others. STs soon realise that they will be working in a very complex environment, and their mentor teachers cannot provide them with all the knowledge they need immediately.

STs often feel that their preparation is not enough when they go into their first school teaching experience (Darling-Hammond, 2006). However Ronfeldt and Reininger (2012) stated that STs’ after- practicum perception of their preparedness is better than before practicum. One might argue that STs probably received positive influence and/or positive feedback during their practicum. However, Ronfeldt and Reininger (2012) argue that STs’ beliefs are influenced, amongst other aspects, such as STs’ perceptions of their capability to: teach their subject matter, deliver engaging and meaningful lessons, plan them effectively, and be able to use a range of methods. This study is not conclusive in this matter but, it can be argued that, the extent TEs have positive influence on their STs is a relevant factor in their perception of preparedness to teach. TEs could help STs in trying to grasp complexities about teaching and learning. Furthermore, positive influences were observed when STs saw that their TE’s teaching model, observed during their method units, was useful in shaping their own teaching actions (Lunenberg et al., 2007; Nilsson & Loughran, 2012).

As was stated previously, most STs have been configured by their prior expectations about teaching during their experience as students within their own schooling. They often have a belief that teaching is easy, less complex and less demanding than it actually is (Loughran, 2006). For instance, most STs did not think about student pre-conceptions and how challenging these can be to change. When this idea is presented to STs they usually experience a significant impact on their personal view about learning within a science class. TEs could play a significant role in helping their STs to reduce the gap between theories (what is known) and practice (what they are able to do). However, how much influence a TE has within a method unit in a teacher preparation program is still unclear (Nilsson & Loughran, 2012). This study seeks to make a contribution to this question by offering to explore to what extent a TE’s learning intentions helps their STs to develop their own science teaching pedagogy.

1.4 Pedagogical Reasoning

When Shulman (1987) presented his model of PR, one of the aspects, that had been taken for granted, was that there is a knowledge base for teaching - something that is possible to be observed, evaluated and learned during teaching programs. In Shulman´s arguments that was just a belief, and over that belief there were no solid ground which could sustain that belief within teacher education. Shulman presented and advocated that a particular content knowledge and the strategies to teach it are in the mind of a teacher when trying to make that content accessible for their learners. In consequence, they make decisions based on their “wisdom of practice” (Shulman, 1987, p. 11).

Shulman (1987) viewed the art of teaching as “an act of reason, continuing with a process of reasoning, culminating in performances of imparting, eliciting, involving, or enticing, and is then thought about some more until the process can begin again” (p.13). He then offered a six-stage model of “pedagogical reasoning and actions” that was cyclic by nature. This model included the following stages:

- comprehension (understanding what is to be taught);
- transformation (how to represent the content for teaching);
- instruction (the enactment of the representation);
- evaluation (checking student understanding)
- reflection (personal thinking about all of the above stages); and,
- new comprehension (what was learned from these processes and how might it be taught differently) (Shulman, 1987, p. 15).

1.5 Exploring the Pedagogical Reasoning of a Physics Teacher Educator

TEs’ practice and PR have been shown above to be important in their STs’ learning about teaching. However, how TEs teach and develop their expertise and experience in their own practice has not been studied sufficiently. Geddis and Wood (1997), John (2002) and recently, Berry and Van Driel (2013) argue that there is a need for research in this area. The PR of TEs, and its impact on their students, have not been explicitly written up nor analysed in academic literature. Therefore it is important to research how a TE perceives his own PR, and to what extent it impacts STs’ learning, and also explores its connectedness with STs’ views and expectations about the unit delivered. The literature reviewed, showed that most of the research is related and/or is included in the field of science teaching and learning. The selection of a physics teacher educator was because the researcher has a background as physics teacher and also as mentor teacher, in consequence a great interest on exploring that specific field of science education.

Research question

The research question of this study developed out of the concern above and is articulated in this thesis as such:

How does an experienced physics TE perceive, express and interpret their own PR and how might their PR impact on STs' learning?

The aims of the research are to:

- Explore and clarify the PR of one physics TE while teaching a discipline method unit: pre-, mid- and post-teaching; and,
- Explore the extent this TE's PR is connected or disconnected with their STs PR, and how that might impacts on their perceptions of learning about how to teach and learn physics.

1.6 Thesis Outline

The study is focused on exploring the PR of one physics TE during his teaching of a physics method unit in a Master of Teaching graduate program of education (secondary years). The unit was delivered within a public based Australian university over one 12-week semester.

Chapter 2 presents, firstly, an exploration of what has been researched on teaching and learning about teaching but keeping a focus on science teaching. Then PR, as a framework from which TEs' practices can be explored and articulated is reviewed. Thirdly the literature is used to build arguments about why is relevant, in the field of Teacher Education, explore the PR of a physics TE from his own point of view, and connect that with his STs' perceptions. Finally, an overview on the actual field of research on TEs is included.

Chapter 3 includes the designed methodology to capture views and beliefs of an experienced physics TE about his own PR, and how it impacts on his STs' learning. To enable data capturing, it was used an interpretative phenomenological analysis (IPA) as a framework because this qualitative methodology allows and encourages personal expressions "in its own terms" (Smith, Flowers, & Larkin, 2009, p. 1). It is relevant for this study to explore how this physics TE perceives his own PR, and how it is perceived by their STs. Allow both perspectives might increase its reliability. This chapter also includes a discussion about its validity and quality, presents limitations of the research, and includes its ethical commitment.

Chapter 4 includes data analysis. Firstly, the physics TE's condensed profile is included. Then, his approach, beliefs and views, were tried to be captured in attempting to allow an initial induction into the data. After that, four themes within TE's expressions were detected, and interpreted.

Chapter 5 includes three discussions. The first one is about the TE´s beliefs and views, and how those can be seen as his comprehension of the unit (what physics and teaching physics are about). The second discussion tried to capture the transformation and instruction stages within the TE´s PR. The last one is about the key role played by ST's feedback within his PR and how that allows him to arrive into a deeper comprehension about learning how to teach physics.

Chapter 6 includes conclusions, limitations and implications of the study. Some ideas for further research are included. For instance, how far beliefs and views about teaching science, affect science TEs' PR, and also over exploring other science TEs' PR to clarify each individual own practice, and explore common practices, if any.

2. Literature Review

2.1 Chapter Structure and Overview

This chapter presents a review of the literature and is divided into four main sections. The first section explores studies that have researched teaching and learning about teaching and, particularly, about science teaching. The second section presents and describes pedagogical reasoning (PR) as a framework from which to view teachers' reasoning and actions in the teaching and learning process. By exploring PR it is possible to investigate parts of the cognitive and metacognitive processes involved in developing successful expertise in teaching about teaching science. The third section uses the literature to develop arguments about the aim of this study and why it is necessary and important. It provides the impetus about the specificity of this study; that is, why it is important to research a physics teacher educator (TE) and his PR about his teaching and about his own student teachers' (STs') learning when they are learning about teaching science. The fourth section provides a general overview of the three major research areas on TEs: competencies that underpin TEs' teaching, TEs' background and personal previous experience in building up their practice, and the self-study of teacher education practice. This provides a framework of that which has been explored and helps to justify, in advance, why and how the present study provides another perspective to this research field.

2.2 Teaching and Learning about Teaching

Shulman (1986) reported that there are many wide ranging ideas about what it means to teach and learn. At one extreme, there are those who indicate that teachers just need to know the content of a particular subject, and then, in terms of disseminating that knowledge, they will be able to develop their teaching during practice. At the other end of the spectrum, there are those who argue that teaching can be seen as a set of teaching competencies, where teaching is vastly complex and not just focussed on the content alone (Shulman, 1986). To Darling-Hammond (2006), subject matter knowledge is definitely required for teaching but the teacher has to be mindful about developing strategies and methods appropriate to each class' context that enhances students' learning. One approach in reaching that goal is included in the idea of role modelling. In the role of TE, it is expected that their practice, as exemplary teachers, should permit their STs, not just to experience what good teaching looks like, but to explore it, connect it with its theoretical basis and also analyse and criticise it. For instance, in a study conducted by Lunenberg et al. (2007), the researchers were trying to capture TEs´ modelling behaviour when teaching their own STs. It was observed how TEs translate theories about teaching and learning within teacher education programs. Unfortunately, modelling seems to be a good idea rather than a regular practice. However, the study contributed to this group of TEs in increasing their awareness on their approach and the relevance about clear it up for their students to better contribute to their learning about teaching. Then, how a TE teaches, and how clear for their STs their behaviour is, seems to be significant in learning how to teach.

Several studies have been researching how to better understand the close relationship between teaching and learning within general, non-specific content areas. Indeed some of the researches have been exploring specific topics within particular content areas; for instance, and just as an example, Brass, Gunstone, and Fensham (2003), explored what quality learning meant for a group of high school physics teachers and for a group of university physics teachers. They found, that for most tertiary teachers, learning is more connected with their own views about the nature of physics, than with their students' knowledge, so they held a teacher-centred approach when talking about learning. Also when they talked about quality it was connected with students' adequacy or ability to learn. To Brass et al. (2003), tertiary students' feelings of dissatisfaction about their physics units are highly connected with their teachers' practice and beliefs about what is learning, and what learning is about. Another example of that is a case study research of a mathematics TE conducted by Geddis and Wood (1997). Within this particular case study, Geddis acted as researcher (as an inner observer or critical friend), while Wood, a mathematics TE, was the participant and researcher. They attempted to explore and recognise how a mathematics TE acted to transform subject matter for his learners and, at the same time, be self-aware and work with his STs in developing their own reasoning to be able to recognise the nature of teaching mathematics and the dilemmas that they needed to deal with. Another example in a different area of education, information and communication technology (ICT), teachers and researchers have been clarifying their role and their pedagogy within a dual dilemma paradigm. On one hand ICT can be seen as an omnipresent knowledge, skill, or competence, which could be considered included within the teaching of each specific subject matter or, on the other hand, as a specific subject matter itself (Webb, 2002). The dilemma still exists in current research, and also within teaching and teacher education, so ICT TEs need to handle this dilemma and encourage other teachers to be able to develop their competencies in ICT. Hence, researching on both extremes of what does mean teaching and learning in Shulman's (1986) view; teaching as a matter of practice and teaching as a matter of competencies, are both worthwhile.

Within teacher education, each subject matter constitutes a vast and complex area to research. They can be analysed from different perspectives. Within science, which is the area of interest in the actual study, students are influenced by the world they live in and change is frequent. As such, it is relevant to research science teaching pedagogy as flexible, ever-changing knowledge. It, is also important to investigate how other factors, such as culture, students' upbringing, learning environments (classrooms and schools), communicational media, behaviour, impact on science teaching and learning (Anderman, Sinatra, & Gray, 2012). On the flip side, it is important to research science teaching and learning from the TE's perspective. Clarifying TEs' concerns and why those are relevant or important for them, and how they construct and enact their approaches to teaching how to teach science, is relevant too (Berry & Van Driel, 2013). Furthermore, in the case of science, reflection on learners' ideas about science and helping them understand the actual nature of science (the nature of the subject matter itself) has been argued to be more relevant to know. How the science works is more important than its products, laws and formulas (Taber, 2014).

New approaches and old dilemmas coexist in the field of science teaching and learning. For example, exploring and understanding the history and philosophy behind science is seen nowadays as a key practice in understanding what science is, where it has come from and to provide its rationale. This approach has been researched in trying to reduce naïve concepts and misconceptions which are usually held by students (and by teachers too) in their approach to science learning (Kindi, 2005; Monk & Osborne, 1997; Solomon, Duveen, Scot, & McCarthy, 1992; Teixeira, Greca, & Freire, 2012). It was researched how students' views and regard for science, as a subject matter and for science learning, had changed over time. It seems that this approach affected them positively, not just in their comprehension of science but in improving their learning behaviour and engagement in science (Teixeira et al., 2012). This can be seen as a significant contribution in developing a pedagogy of science, nevertheless, the impact on teaching practice is still limited but, hopefully, it is gaining more impetus (Höttecke, Henke, & Riess, 2012). Therefore, a TE has to deal with old dilemmas, such as the practice of science teaching, and new approaches within science teaching and learning - not just in regard to general teaching but also related to specific pedagogical approaches, when planning, undertaking and evaluating each class and specific content. Science teacher education is continuously changing and developing. Complexities are part of every class and therefore understanding TEs' learning intentions might be helpful in unveiling how they deal with these complexities for and of teaching.

Teaching could be observed as practice based and highly individualistic, therefore STs are in danger of not having sufficient tools or experiences to be able to develop their own pedagogy. Even though, the teacher education field might offer a variety of pedagogies, teaching experience is highly significant in shaping STs' thoughts and practices and in developing their pedagogy. Furthermore, every mentor teacher also has particular approaches to help STs in developing their own pedagogy (Chastko, 1993). Experienced teachers have developed their own perceptions about what "good teaching" means (Chastko, 1993) and what kind of actions are involved when they are helping and mentoring beginning teachers within mentoring programs (Hellsten, Prytula, Ebanks, & Lai, 2009). Each mentor teacher holds their own beliefs when it comes to practice. Chastko (1993) advocated for an early approach to develop an understanding and awareness of PR within method courses in teacher education. Learning to teach, as in all kinds of learning, is significantly interwoven with personal and social experiences. The extent field experience shapes and influences STs. If they do not start developing their own reasoning about teaching and learning could become a problem in developing further skills that enable them to develop their own effective pedagogy. Method units can influence and help STs in recognising what good teaching looks like, and how they can approach developing their own pedagogy. Helping STs to shape their identity by working on self-reflection skills, and also helping them to analyse and know the social context of their practice, can assist them in adapting their pedagogy (Hellsten et al., 2009; Timoštšuk & Ugaste, 2010). It is suggested that, in clarifying explicitly what the goals for STs within their practicum will be, should be a significant step to reduce negative effects on the development of their own pedagogy. This could include particular attention on developing teaching plans, encouraging self-reflection, and developing their PR. It could help STs in taking alternative actions during their teaching practicum (or even after that), as a valuable learning situation for them as new coming teachers.

How can all of these ideas be considered in developing a method unit within a teacher education programme is a challenging problem, not just because of the content to be included but for its role in teaching how to teach, as well as modelling that teaching for their STs. A self-case study conducted by Geddis and Wood (1997) attempted to reveal the complexities that faced Erik Wood during his course within the apparently simple content area of integers. It is not the content but the transformation and dilemmas that he faced in exploring his STs' thinking and in using that as an example to deal with some very fundamental questions; how do I teach it, why is it important, how can I manage it and use it as a tool that will able them to learn how to teach? (Geddis & Wood, 1997). The answers could be found in exploring Wood's thinking and his pedagogy in action when: helping his STs to develop their skills, in lesson plan making and in developing their own pedagogical reasoning. A few years later, after Wood's teaching dilemmas, John (2002) explored TEs' experiences. Two participants, a mathematics TE and a science TE, used their classes to model lessons to explore STs' conceptual misconceptions about the subject. They also used their lessons as an experience to analyse their own pedagogical approach, and to listen to their STs' thoughts about their approach. In learning about teaching, TEs have a significant contribution to make when they can explicitly explain their planning and teaching actions. It is also observed that TEs implicitly teach their STs by using themselves as a model of what good teaching looks like.

2.3 Pedagogical Reasoning

There are a plethora of ideas and approaches about what might constitute teachers' PR (cf. Shulman (1987), Meredith (1995), James and Scharmann (2007), Starkey (2010), Mercier (2012)) . As a current concept which is being analysed and used by many educational researchers, it is important to articulate the definition of PR adopted and used in this study. The first area to explore is pedagogy. This involves what is meant by teaching and learning, teacher's actions within practice, and critical thinking about issues within that practice (Loughran, 2006). Acquiring particular subject matter pedagogy seems like a skill which only could be mastered with practice. In that sense, good pedagogy could possibly only be observed in experienced teachers' classrooms. However, there is argument that early STs' introduction to pedagogy of teaching could help them in coping with their concerns about teaching before starting to teach (Nilsson, 2009; Peterson & Treagust, 1995). If STs start earlier on developing their own pedagogy they might be able to deal with their students' concerns about learning and reflect on how effective (or ineffective) their teaching procedures might be.

In developing a pedagogy of teaching, the following knowledge might be included: the subject (content knowledge), how to transform it and teach it in a way that would be understandable and learnable by students (pedagogical content knowledge), being aware about students' preconceptions, how a particular way of teaching can be examined during the class, and to recognise if it was successful or needed changes (self-awareness about teaching and learning). Shulman (1987) explained the art of teaching with a six-stage model of "pedagogical reasoning and actions" (p. 84) that was cyclic by nature, as is shown in Figure 1.

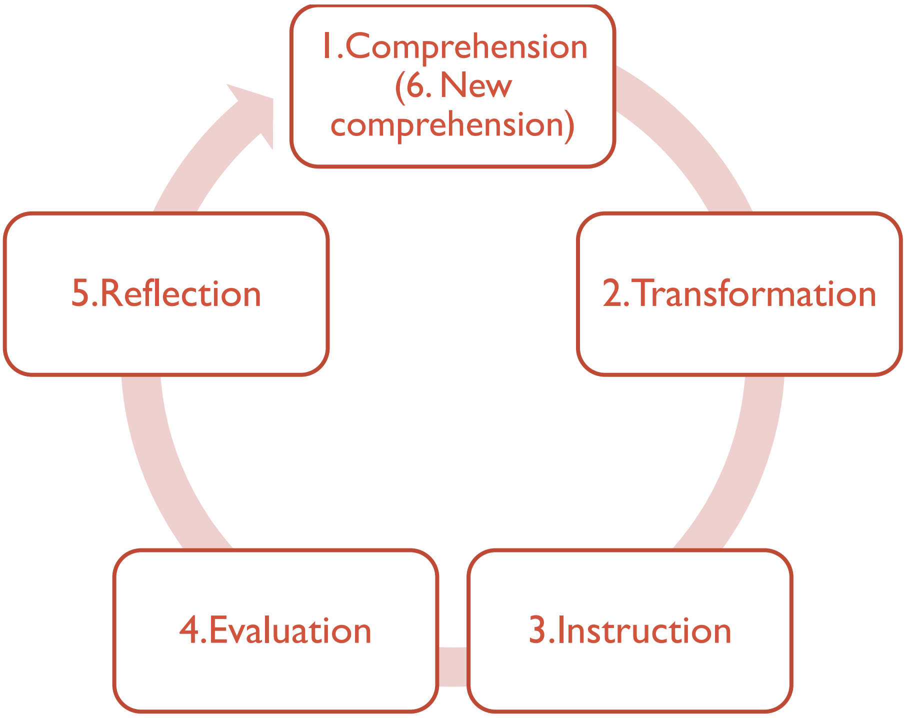


Figure 1 Shulman's Pedagogical Reasoning Model

The actions that a teacher should develop, included in this model, start with a teacher having well-developed comprehension of the content to be taught. They have to have a firm understanding about the content and there must be a great deal of thought about it and about other related concepts (Shulman, 1987). The first stage could be extended to think about known misconceptions, as well as common questions that students will probably ask. The second stage involves what a teacher knows about their students; for instance, their background and their year level. In short, what students know about this particular concept and about other ideas, knowledge and skills that students have or do not have yet. So, teachers must transform the content and enable it to constitute a challenging, but accessible problem for students (Nilsson, 2009). The third stage is constituted mainly by instruction delivering. This stage is where experienced teachers reveal their expertise when delivering engaging experiences with their students and also their ability to facilitate, in a meaningful manner, a learning environment for addressing students' issues (Youngs & Bird, 2010).

Shulman (1987) expresses that how a teacher behaves, within this stage, is highly related to their comprehension and how connected their students are with their subject matter transformation. The fourth stage, evaluation, is highly tied, in Shulman's (1987) view, to getting feedback from students. It is not just to give marks and grades to students but more importantly getting from them a sense (and evidence if possible) about how deeply they understand the content. The teacher should be aware if there was a particular misunderstanding or some general deviation from the concept that was expected to be learnt (Nilsson, 2009). The evaluation can occur within the same class or after it. In that sense, evaluation is closely tied with stage five, reflection. At this point, teachers have to think about why their teaching leads their students to learn the way they did. Also teachers have to think about their influence on them as a role model, why the discussion leads the lesson in one way or another, as well as comparing the actual class with another that they had done previously. This process often involves a reconstruction of what happened during a teaching period and connect it with the planning stage, and all previous stages (Nilsson, 2009). The last stage, new comprehension, is not just about the content knowledge and the way a teacher transited through the cycle. Obtaining new comprehension also takes into account the selected approach, environmental situations, emotions experienced by students and by the teacher, and other such internal and external factors. New comprehension usually does not come immediately or after the reflection stage - it normally takes longer (Shulman, 1987).

Within this process, every attempt of teaching a particular concept could be seen as a rational and professional action in order to improve and better achieve learning intentions, whatever they are. As a model it has limitations. Meredith (1995) observed that individual socio-cultural experiences shape teachers' approaches to their teaching in several ways. For instance, in building their teaching, in developing their pedagogical content knowledge, and in the way that they think about their own teaching and why and how their students could better achieve their learning intentions. For Meredith, TEs need to be aware of, and to what extent, previous learning experiences shape STs' PR. In exploring STs' PR, Nilsson (2009) analysed prior ideas of learning about teaching, then designed methods to introduce and challenge those ideas with the purpose of moving beyond transmissive pedagogies. Nilsson (2009) observed that during critical events, STs were able to recognise, analyse and develop reasonable understanding about what factors were relevant. She recognised at least three important elements to develop their PR. Firstly; STs were capable of distinguishing to what extent they needed to make a real connection with their students and to interact with them, rather than just to talk them or instruct them. Secondly, they thought about how and what motivates their students. Finally, they were able to develop their own learning about how to teach science. Nilsson (2009) affirmed that it was important to distinguish STs' concerns when they were involved in the method unit; in doing so, she was expressing her own PR. She transformed the method unit content knowledge by being informed by her STs' concerns and preconceptions. A further step forward from Nilsson's research might be then to explore and capture holistically an experienced TEs' PR when teaching about how to teach. And that is the purpose of this study.

2.4 Ways of Developing Student Teachers' Pedagogy

The three main actors within Teacher Education programs are STs, TEs and mentor teachers (when students are on practicum). A likely assumption is that TEs know a great deal about pedagogy, including their own pedagogy when teaching their STs. However, not so much it is known about TEs' pedagogy (Berry & Van Driel, 2013; Bullock, 2012a; John, 2002). Therefore, it might be important to explore this and the influence it might have on their STs' developing pedagogy.

Neither STs, nor mentor teachers can clearly express or explain their own PR (Nielsen et al., 2010). One might suppose that is probably because they have not previously been asked to explain and analyse their practice. As novice teachers, STs, when asked to analyse their teaching, mainly describe their experiences focused on their activities and their own emotions (before, during and after their teaching rounds) rather than on students' learning, or on their own PR (Timoštšuk & Ugaste, 2010). On the other hand, as was researched by Chastko (1993) and Nielsen et al. (2010), mentor teachers, experienced difficulty in expressing their own pedagogy. If they could, this could be helpful for ST´s learning about how they can learn to teach. It is therefore hard, for mentor teachers, to help their STs on reasoning about their own approach and to develop their own pedagogy. Within Chastko's (1993) research, mentor teachers followed a pre and post lesson discussion about their own approach and experience in teaching with STs. A group of experienced mentor teachers were researched while, in parallel, they were interacting with their STs. Some of them could not unpack their comprehension and transformation of the content knowledge. Moreover, some of them could not explain why they taught the way they did, or how they came up with a particular approach to teach that particular concept. The thinking behind their practice remained hidden and inaccessible to their STs. However, other mentor teachers engaged more actively with their STs as they knew that it was somehow important for them. Sometimes, these mentor teachers were able to express their own teaching and unpack that within their conversations. During that experience, even though they have had different approaches on mentoring STs, none of them were clear about or encouraged STs to unpack their own subject matter comprehension, or how they transformed it into being able to get their students engaged and willing to learn. In general, mentor teachers see their own skills and ways to teach as natural and simple but they find it difficult to unpack or make that clear for their STs. A research conducted by Der Valk and Broekman (1999) explored how STs developed lesson plans prior to their first practicum. STs, without any formal experience of teaching, were asked to write a lesson plan that introduced a concept in a 40 minute class. After that, they were interviewed to report their lesson plan and were asked to reveal if their content included any pedagogical content knowledge. As a result, they were able to argue about students' prior knowledge, justify their strategies, and explain why they chose a particular way to teach and how that could affect their learning intentions. The study showed that this intervention helped STs to develop their abilities to recognise their own pedagogical content knowledge, and as a consequence they were able to improve their own pedagogy. It also introduced them to the importance of reflection on their pedagogy in an early stage of the course.

By not encouraging STs' early development of their own PR could be seen as an issue that may limit their experiences within their practice. Early development of reflective teaching and explicit PR could help to improve STs' practicum experience (Nielsen et al., 2010). It is also relevant that during teaching rounds and in observing expert teachers, STs could start to construct their own "wisdom of practice" (Shulman, 1987, p. 11). Sánchez and Llinares (2003) explored four mathematics STs' PR before their master of teaching course started. The researchers suggested that each ST shaped their teaching approach based on how each one constructed their own subject matter knowledge. That approach might have been changed within the mathematics method course if they had the opportunity to develop their own PR.

During STs first years of teaching, when their skills and knowledge about how to teach are limited, it is also important that they see their failures as a way to master their own pedagogy. A sensation of failure could stimulate deeper reflection and the ability to think about what teaching strategies may have been used instead. If they viewed their master-ship of teaching as a cyclic process, it might enable them to improve a little bit each time. For Nilsson (2009), teachers' PR could be seen as a process that allows an interconnectedness between theoretical knowledge, about pedagogy and subject matter, and STs concerns when teaching particular subject matter. An explicit impetus to develop STs' PR by a TE might help them in addressing their concerns (and fears of failure) about teaching, and to give them skill in reflective thinking about their practice. Exploring a TE's PR could offer an alternative perspective. How a TE conceives, explains, argues and expresses their PR and how they connect/model it with their STs could offer an opportunity to explore how this might be useful in the preparation of STs for the classroom.

2.5 How Teacher Educators Observed their Own Pedagogical Reasoning

Many studies conducted about TEs, as is explained by Berry and Van Driel (2013), can be grouped within three major areas: competencies that grounded TEs' proficiency, TEs' background and personal previous experience in building up their career, and self-study of teacher education practice. The third group, self- study, one might argue is more likely connected to this study because it keeps the focus on TEs' practice (Bullock, 2012b) and their own experience as TEs. For instance, the self-study conducted by Geddis and Wood (1997), sought to examine Shulman's (Shulman, 1987) transformation of subject matter in the context of a mathematics unit. It was about how an experienced TE introduced their STs to mathematics pedagogies and walked with them through the unit while clarifying and attempting to change their misconceptions about it (mathematics pedagogy). Many representations of mathematics pedagogy and strategies to enable STs' connections with what does mean teaching mathematics emerged. Within this research, the focus is on the TE's actions and STs' responses within a particular lesson. The study reflected his PR in the stage of transforming the subject matter from the perspective of the TE and the co-researcher. Having said that it could be interesting, to clarify connections with all PR's stages of experienced TEs to complete the picture about their own perceptions when planning, teaching, and evaluating a method unit. That is one of the purposes of this research - to gain insight into a TE’s own perceptions of his PR. Phenomenology might help to capture TE’s meanings, main ideas, learning intentions and teaching nuances that build up their PR.

How TEs develop their perceptions of their PR and what is included in those perceptions is relevant for this study. TEs’ approach to teach how to teach and learn, sometimes, evolves from (or into) a set of principles that underpin their thinking in action when teaching. For instance, Bullock (2012b) explained that he has five principles to work with his STs. Those principles are expression of his beliefs and practice. For instance, to question the validity of what STs think about what teaching entails, he belief that it is a difficult task. Firstly it is necessary provide the STs with an opportunity to recognise their ideas about what teaching they think it is, and then challenge it. It can be observed similarities with Geddis & Wood’s (1997) ideas when they advocated to develop their STs’ pedagogy. However, to develop such pedagogy, meaningful experiences have to be provided because they need to experience it (Loughran, 2006). Bullock (2012b) also recognised that teacher knowledge is often tacit and difficult to have them open up, therefore an effective tool is needed that explicitly can unpack it.

Similarly as other studies about teacher education and on TEs, Bullock (2012b) was able to recognise his troubles, however, his STs, were mostly absent or had a minimum voice about their learning experience. In regard to STs learning experience, Freese (2006) intensively studied a particular ST’s experiences and emotions during their struggle within a teacher education program. Over two years, the ST journalised their feelings, worries, reflections, dilemmas and successes during a master of teaching program. Through journaling, the researcher pointed toward that from this participant she obtained valuable insight for her practice as TE, because she was able to look at her practice from the ST’s perspective and found that, sometimes, she misinterpreted her ST’s behaviour. Freese (2006) also stressed the point that connections between TE’s learning intentions and what STs’ get out of the course, is an area which is in need of more research. The present study is committed to explore the PR of an experienced physics TE, not just from the TE’s perspective but from STs’ perspective too.

Within programmes of teacher education the “content” is not the subject matter that novice teachers should teach shortly. Understanding why and how to teach, and how people learn are important. For instance, developing, or at least, introducing STs to recognise and be aware of misconceptions and naïve student’s conceptions are important instead (Berry & Van Driel, 2013; Geddis & Wood, 1997; John, 2002). However, studies conducted on STs’ PR observed that TEs´ work could be better enhanced. For instance, Nilsson (2009) suggested that STs could improve their pedagogy, and increase their understanding about how problematic learning to teach is, if they observe and analyse critical episodes and events after each class. With experiences such as these, it encourages STs to be more purposefully reflective and cognitively engaged in evaluating particular pedagogical approaches; thereby STs will be more successful in constructing their own pedagogy. Nilsson (2009) stressed the point that PR is not as simple as being mindful about teaching. For her, this cyclic experience, which starts at the planning stage, while thinking in advance about how concepts or content could be transformed to be learnable, needs a stimulus to clarify and extend their actual ideas about learning. STs need to keep in mind that teaching is complex. Incidents during teaching and their evaluation focused on to what extent their learning intentions were met, will generate not just new comprehension about the content, but about their pedagogy, and in exploring ways to better teach and learn. The study conducted by Nielsen et al. (2010), of a community of TEs and cooperating teachers (mentor teachers) indicates, to some extent, a pedagogical disconnection between mentors and STs. In consequence STs cannot observe their mentor teachers' "wisdom of practice" (Shulman, 1987, p. 11). A two year program was held of conversations with a group of TEs and cooperating teachers who supervise teacher candidates during their practicum. The conversations were an opportunity to analyse issues, interests and understanding in being a cooperating teacher. The experienced teachers expressed concern that in order to develop effective STs, the STs need constant prompting to reflect and explore their own reasoning behind their teaching. As was argued in Chapter 1, TEs can act as a model for STs. So, to what extent the PR of a TE is observable and learnable by their STs, and to what extent that is relevant for them, is an actual question which is attempted to be explored in this study.

2.6 Chapter Summary

This chapter established that, within the field of research on TEs' PR, much of what has been researched was indirectly related to TEs' PR. Research studies were mostly about TE's comprehension of their subject matter pedagogy, STs' ideas about PR and STs' struggles in learning about teaching. The existing research has found that TEs' behaviour when teaching and TE's beliefs about teaching, learning and pedagogy, seemed to be highly connected with what STs perceive what teaching is about and how they will develop their own pedagogy when they enter into the profession. Then, it is relevant how TEs might influence their STs in purposefully helping them with early development of their own PR. As a consequence of that, STs will increase their awareness about their own students' learning and their own pedagogy (Chastko, 1993; Hellsten et al., 2009; Nilsson, 2009; Peterson & Treagust, 1995; Timoštšuk & Ugaste, 2010). STs' early development of their PR has been shown promising results in the research because evidence has shown improvement in their readiness to teach (Chastko, 1993; Der Valk & Broekman, 1999; Nielsen et al., 2010; Nilsson, 2009; Peterson & Treagust, 1995; Sánchez & Llinares, 2003). However, for STs developing

PR is neither an easy nor an obvious exercise, so one way to start its develop is through teacher education programs (Der Valk & Broekman, 1999; Herman, 1998; James & Scharmann, 2007; Youngs & Bird, 2010).

Within teacher education, the instructional stage of Shulman's (1987) PR model might play a significant role. At this stage TEs will not just play the role of expert teachers but model their own expertise in a clear manner that enables them to move beyond transmissive pedagogies (Nilsson, 2009). In so doing, the research indicated that TE's teaching seems to be tightly connected with STs' perceptions about what they learnt about teaching. In consequence, it could be significant to investigate TE's beliefs and own perception about their PR and STs' expressions about it because they are complementary sources of data. In this study, both perspectives were included to explore a physics TE's PR.

3. Research Design and Methodology

3.1 Research's Aim, Overview and Chapter Structure

This study is an attempt to explore how an experienced physics teacher educator (TE) views, perceives and reflects on his own pedagogical reasoning (PR). This research also aims to explore the connection (or disconnection) between his PR and his student teachers' perceptions about his pedagogical approaches used when teaching. Nilsson and Loughran (2012) recognise that, no matter how extraordinary a physics method unit might be delivered, student teachers (STs) will continue learning more effectively while they are reflecting about their own teaching experience. TEs might expect that, after teaching a method unit, their reflection about their own teaching and learning, hopefully, might enable their STs to develop their own pedagogy. This study analysed a TE´s PR, including his thinking behind his practice, when teaching a physics method unit. It was also relevant then to research how STs recognised links between their TE´s learning intentions and their own developing PR. By analysing specific episodes and situations within teaching a physics method unit, this study attempts to characterise one particular physics TE's PR and his STs' experience in learning how to teach physics, in learning about physics, and in learning how people learn physics.

This chapter describes the methodology used in the study. It first presents details about how interpretative phenomenological analysis (IPA) is used as the main framework that allows exploring and capturing the meaning given by the physics TE about his own PR. Secondly, it presents the reasons behind choosing Shulman's (1987) PR model as a way to analyse and thoroughly explore the TE's views and beliefs. Thirdly, the process behind the data collection and subsequent analyses, including the STs' views is explained. Finally limitations and ethical issues are presented and explained.

3.2 Capturing Pedagogical Reasoning

3.2.1 Interpretative phenomenological analysis as the main framework of the study.

IPA is a widely used methodology. It involves the researcher capturing and articulating participants' views and beliefs when they talk about their own experiences (Smith & Eatough, 2007; Smith et al., 2009; Smith & Osborne, 2008). For this study, IPA will help in capturing both, the TE's views and beliefs of their PR, and his STs' perceptions about their TE's PR. In this way, it would be interesting to see if the teacher's views on his own PR match or could be validated by his STs' views on his PR. In particular, the IPA methodology helps to capture:

- a TE's thinking behind his practice, which includes views, beliefs, perceptions, interpretations and reflections about his own PR; and,
- his STs' experiences, views, beliefs, perceptions, interpretations about their TE's PR and the impact this may have on their learning experience about how to teach physics.

Phenomenology gives relevance to how things are perceived (Gallagher, 2012). In that sense, how the data is captured is relevant and how the methodology provides space to the physics TE to not just explain, but also for the researcher to observe his practice, is important too. It plays a significant role in gaining insight and in keeping the research focusses on his "wisdom of practice" (Shulman, 1987, p. 11).

The phenomenon analysed in this study is the PR of a physics TE. The most important thing is to capture the essence of the experience, and the meaning given by participants (Giles, Smythe, & Spence, 2012).In this study, the data will include observations of the TE's classes, interviews with the TE and his STs and a STs' survey.

3.2.2 Data collection within the study

Interviews were a major source of data in this study. Semi – structured interviews allowed the participant/s to engage in dialogue with the researcher. This approach helped to draw out participants' concerns and beliefs, and provides the opportunity to follow up some of their comments and to gain more detail where relevant (Smith et al., 2009). This is key when following an IPA methodology. It is also important that data collection should not be influenced or biased by the researcher. There should be distance between the researcher's preconceptions, and participant's perceptions, beliefs and actions (Shinebourne, 2011). Class observation provided another data source, where the researcher's interactions were limited. An interview at the end of each class allowed the TE to comment on his perceptions about his own PR based on his own actions in that class. Class observations were also helpful in prompting conversation either with the physics TE, as well as with STs. The semi structured interviews and class observations played a significant role in capturing perceptions and views about the physics TE's PR both from his own interviews and the interviews with his students.

"Physics education in the secondary years B", is the second unit of a two-part discipline unit that is taught in the graduate diploma of education at a particular Victorian university. The degree is taught full time over two semesters. The second physics unit must be taken in conjunction with part A, in a consecutive manner. The TE and their STs were observed during the complete second unit. In trying to capture the PR of the TE, his views and beliefs were discussed using semi-structured interviews that explored each phase of his planned teaching and his reflections, as well as his approach and his pedagogy. Open questions were asked, such as what is important in this lesson, why is it important, how is the TE going to teach it, and why is he teaching it that way? The interviews also included discussions of the planning stages through to reflection stages. At the end of each class observation, the TE was also asked to reflect on what could have been done differently to better achieve his learning intentions. STs' perceptions and experiences were captured mostly at the end of the unit through an anonymous survey, and personal interviews. However, some of their questions, ideas and reflections presented or asked within classes were quoted where relevant in describing the TE's PR.

3.3 Shulman´s Pedagogical Reasoning Model as a Framework for Exploring a Teacher Educator's Pedagogical Reasoning

To be able to analyse the data, this IPA study used the stages developed by Shulman (1987) as a lens from which to unpack the TE's PR. In this study, the six stages of Shulman´s (1987) model of PR and action was used to explore a physics TE's teaching in action within a structure that enables the physics TE, as well as the researcher and the readers, to get into his "wisdom of practice" (Shulman, 1987, p. 11) in a more articulated manner. This model also situates and unpacks TE's and STs' views, beliefs and experiences. This framework also permits data capture to occur at each stage of the unit. The table below summarises participants' data collected at the various stages. For instance, in analysing the instruction stage it is important to interview the TE for his views on how he teaches the class, but also to collect data from the observations and STs. In doing that, STs' experiences offered an alternate view to that of the TE which is worthwhile to take into account. Both were included at this stage and cross analysis was useful in examining the level of connectedness between TE's PR and its impact on STs' perceptions about what they learnt, how successful they thought the approach taken was, and why it might be important for them. Other stages, such as comprehension, reflection, and new comprehension, just include data from the TE´s viewpoint as the expert in the field; the TE is the sole participant who was involved in those structural phases.

Table 1

Shulman's Stages and Sources of Participant Data

Shulman´s stage	Phase	Participant data collected
1. Comprehension	Planning	TE
2. Transformation	Planning and teaching	TE and STs
3. Instruction	Teaching	TE and STs
4. Evaluation (STs' learning how to teach physics)	Exploring and analysing STs feedback	TE and STs
5. Reflection	Reflecting about STs' learning after exploring feedback and other kind of students' expressions	TE
6. New comprehension	Analysing new meanings. Recognising alternatives tracks to better teach how to teach physics	TE

This model may need slight changes to be adjusted to offer a wider and deeper interpretation of the TE's PR. It will be used as lens from which to understand the process involved of this particular TE's PR. It is relevant to analyse if STs' perceptions of learning how to teach have an impact on TE´s new comprehension. Therefore, there is also a further question analysed in this study - whether or not ST´s feedback, which is neither simple nor trivial, impacted the TE's PR. As is shown in figure 2, this study payed attention to ST´s feedback and how relevant that might be to a TE´s PR.

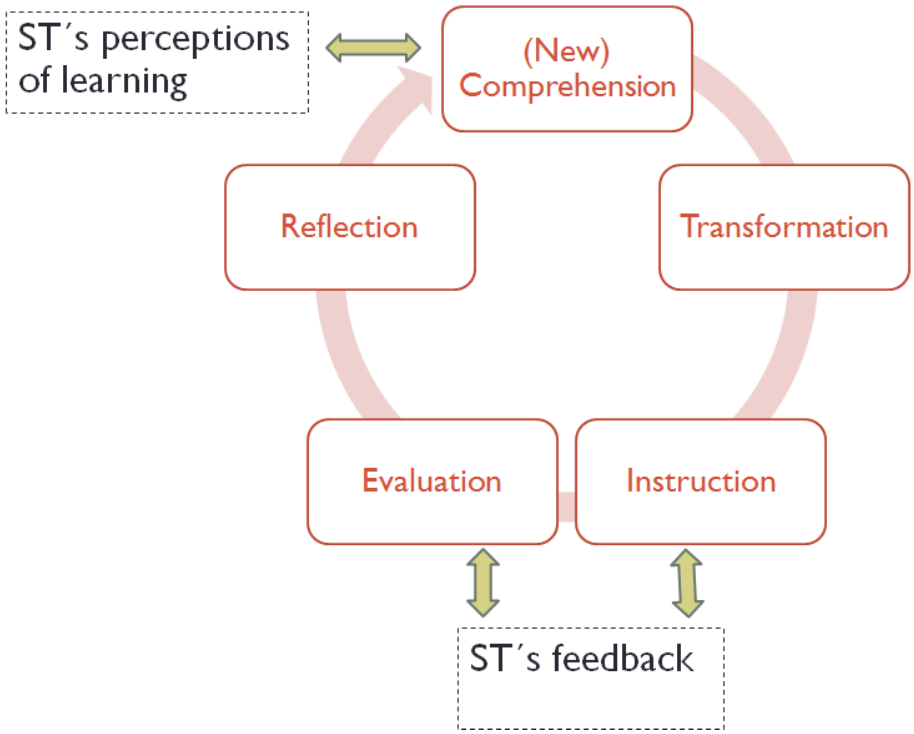


Figure 2 **Teacher Educator´s Pedagogical Reasoning informed by student teachers' feedback**

Every part of each data collection process was analysed using Shulman's model to guide the research. Not as a step by step analysis but as a useful model to situate each experience and its relevance, and also to give appropriate context to the main themes that arose in the data analysis.

3.4 Acquiring Knowledge about the Physics Teacher Educator's Pedagogical Reasoning

3.4.1 Data collection process.

The major focus and more extended data were obtained from the TE. Focused mainly on Shulman (1987)'s planning and transforming stages a pre-unit interview was designed. Then a series of short interviews, after each class, were looking for insights principally on instruction, evaluation and reflection based on Shulman's (1987) stages. Finally, a post unit interview was concentrated on the reflection stage, but explored self-evaluation and new comprehension of the TE. Pre and post unit interviews were around one hour in length each, and each short interview (after each class) was no longer than fifteen minutes. STs' perspectives have been included because they provide feedback on the TE's PR. The first data source was an online survey conducted at the end of the unit to gain an overall and anonymous insight about STs' view on how they perceive their TE's PR, and about their experience within this method unit. The second stage was a personal recorded after unit interview, which attempted to capture the experience in a sample of STs.

3.4.2 TE´s data collection instruments

TE´s pre-unit interview

In exploring the TE's PR, he was interviewed (semi-structured) at length, at the beginning of the semester. The purpose of this interview was to explore:

- How the TE intended to teach the unit, asking for instance, "What are your main learning intentions for students when teaching this physics unit?"
- His pedagogy, by asking questions like, "How do you focus your course to meet your learning intentions/aims during the semester?"
- His lesson plan, by asking him "Could you explain, briefly, your teaching plan/outline of the content being taught and teaching approaches for teaching that content during the unit?"
- And also his particular reasons for so doing, when prompted for instance, "Why do you think those activities/arguments are important and useful and could lead them to improve their own pedagogy?"

A full version of the pre-unit questionnaire is included in appendix A.

TE's weekly interview schedule

After each observed class, the TE was interviewed briefly and asked to comment on his PR in the lesson. The questions asked were structured around each stage of Shulman's (1987) PR model. The following questions demonstrate the types of questions asked:

- Comprehension and transformation stages: "Why did you present the content that way today? Could you explain your thinking during the class that lead you to teach in the way you did?"
- Instruction stage: "Why did you ask that question?"
- Evaluation stage: "How do you know what your students learnt about a specific idea during the class?"
- Reflection/new comprehension stages: "How do you know if the lesson was successful? In what ways was it successful? Do you think the students learned what you wanted them to learn? How do you know?"

These short interviews provided fuller insights about the TE's PR and how the TE's actions can change in the class due to the influence of certain events, and as a result of student comments and feedback within the lesson. The full questionnaire is presented in appendix B.

Class observation: a complement source

Observations and audio recordings of each weekly class were arranged and were transcribed. The transcriptions had two purposes: to recognise and analyse actions that show TE's PR, and to help in asking him about: why did he did what he did, or about his STs' responses and feedback.

TE´s post unit interview

The TE was also interviewed at the end of the teaching unit, over one semester. There was a double purpose for a post unit interview. On one hand, have evaluation and reflection of his PR over the unit. And, on the other hand, to explore what new ideas and comprehension about how teaching to teach physics, if any, he found and why and how did he know that. Examples of some of the questions are presented below:

- “Were your learning intentions/aims successfully achieved during the unit?”
- “How do you know that your students learnt in the way that you taught them with that particular pedagogical approach?”
- “To what extent will the student teachers’ response change your next year’s lesson plan for this unit?”

The complete questionnaire is included in appendix C.

3.4.3 ST´s data collection instruments.

To gain as much data from ST’s perspective as possible, all the STs were asked to respond to the survey and participate in a personal after unit interview. Data collection instruments used are detailed below.

Online survey: a tool to perceive general ideas about STs’ experience

In exploring the impact of the TE’s PR on their STs, an online survey requested STs’ perceptions about how the PR of their physics TE was developed. This instrument included 2 demographic questions (gender and age), to get general information about the participants. It was followed by thirteen Likert scale questions, with five anchors each. To explore STs’ perceptions, Likert scale questions provide graduated responses between two extreme possible answers. Perceptions require an appropriate range to situate a personal experience. The following table clarifies the three attempted research purposes traced to this survey.

Table 2

Likert Scale Questions' Purpose (with representative statements)

Purpose	Number of questions	Representative statement	Scale type (for this statement)
1. Exploring STs' perceptions about TE's learning intentions	3	It was clear that the lecturer clearly covered all learning intentions during the unit.	Frequency (from almost never to almost always)
2. Researching to what extent they perceive that they learnt about teaching physics.	3	My approach to teaching physics has had a significant change during the unit because of the lecturer.	Agreement level (from strongly disagree to strongly agree)
3. Exploring connectedness of TE´s learning intentions and STs perceptions about it.	7	At the end of most classes I knew what the lecturer's intentions were.	Agreement level (from strongly disagree to strongly agree)

Finally six open questions to explore STs' views were included. The first two were focused on capturing an understanding of the STs' views on teaching and learning physics. For instance, "In your opinion, what skills, ideas/concepts, delivered during the unit, were important to you as a physics teacher?" The three following questions asked STs to reflect on their TE's PR, for example, "Explain your thoughts about the lecturer´s teaching approaches". The final question gave space for comments that STs might like to write, in addition or extension of their thoughts on PR.

The online survey is included in appendix D.

Personal interviews

The interviews were conducted at the end of the semester. This data complemented and helped to make sense of STs' perceptions and views from their online survey, and included more detailed insights. Interviews were audio recorded and transcribed. The interview explored general perceptions about their experience as learners, and their perceptions about, whether or not, they felt their skills and knowledge about teaching physics improved during the unit. For instance, the exploration includes:

- STs' learning about teaching physics when asked: "What have you learnt about teaching physics during this unit?"
- Their perceptions about TE's PR, learning intentions and actions by asking: "Were his teaching strategies appropriate in helping you learn to teach about physics?"

Furthermore, using some critical events during particular classes, some questions attempted to explore their perceptions about; what they knew they were able to learn, and to what extent that was successful and relevant for them as physics teachers. They were asked, for instance, "To what extent do you think you were able to learn in those moments?" (The entire questionnaire is included in appendix E).

3.5 Data Analysis and Discussion

To better capture the physics TE's PR, a compact profile and meaningful quotes that represent his view and beliefs about his personal approach in teaching this physics method unit was included first. Those indicative comments situate his PR and introduce the study into what is the essential structure of the unit and his approach to it. From all the data sources, major themes were identified that articulated or captured his PR. The themes often were seen over a number of data sources. Each theme represented his PR in terms of what contributed to develop his planning, what is his thinking behind his teaching, how he evaluates his teaching, and how he reflects. These themes emerged to the researcher as important indicators that might represent and portray his PR strongly. Following the data analysis, a discussion on these themes is included. It is also presented the extent that the research question has been answered, and what things could be done in a different way. From this point it can be anticipated other inquires that could be included in further researched about TEs' PR.

3.6 Validity and Quality

IPA is committed to idiographic analysis and to identify meanings, within a sense making method (Smith & Eatough, 2007). Shulman´s model provides a way to perform analysis on a teacher´s views about his own pedagogy and to clarify his thoughts about it (Geddis & Wood, 1997). All the data gathered were collected to clarify, make sense of and explore a physics TE within his pedagogical thinking-in-action to better understand how and why an expert TE did what he did. As soon as other participants point of view are included, the study reliability is enhanced (Giorgi & Giorgi, 2008). Including STs' views increased the study´s reliability and validity in reporting the findings. In addition, the students' perceptions provided feedback that informed the TE's PR. This feedback might be useful to TEs in recognising, or indeed improving, aspects informed by their STs. Consequently, their PR could be enriched. Meaningful findings rely upon connectedness between participants' experience.

To enrich the study's validity, it includes not just TE´s experiences, but STs' experience too. This study increased its trustworthiness allowing different points of view. Further analysis, about connections between TE´s thoughts and experiences with STs' experiences provided a broader interpretative analysis on this physics TE's PR. This connection, or disconnection, could have an impact on STs' learning about how to teach physics. In this study the main source of data relies on the TE, however it includes STs as a secondary source, and researcher’s view as a tertiary one. TE’s and ST’s approaches are situated in opposite, but complementary places; the physics TE when teaching how to teach physics, and STs when learning how to teach physics. The inclusion of the researcher’s view allowed a fair triangulation within the study.

3.7 Limitations

IPA is qualitative research. It relies on participants’ perceptions and beliefs and their honesty and truthfulness, and so the study can be limited. Furthermore it is a short term study and the data was collected over one semester. Only one TE was observed. It therefore is not generalisable to any other TE or unit.

During data collection, neither, explanation or introduction of the framework from which teacher’s action and teaching knowledge was analysed was presented to the TE, nor to his STs. A different approach, in further research could be explore, in more detail, differences from the perspective of the STs, if any, about the connection or disconnection with their TE’s PR. If such study includes an explicit introduction of PR to STs, as well as to the TE, STs’ PR might be explored too.

It is acceptable and also expectable that, within an IPA research, the researcher engages with the data collection process and in its analysis. Even though, this methodology tries to avoid researcher bias, there may be instances where such bias has influenced the way some data might be presented. However, direct quotes, arguments and actions are included in the actual methodology to enhance reliability about the actual interpretation, discussion and conclusion.

3.8 Ethical Issues

3.8.1 Participants’ consent.

At the beginning of the semester, the researcher had the opportunity to introduce himself and the study to the STs with the permission of the physics TE. The purpose of the research was explained and a consent letter and explanatory statement was given to all (including the TE).

The physics TE voluntarily gave full consent to participate. The STs were asked to participate in three domains of data collection and their responses are described below:

I. Audio recording consent. Fourteen STs allowed it and one did not consent. As a consequence, this participant's input in class audio recording was not transcribed.

II. Participation in an online survey. Eleven STs gave consent to participate, but only seven of them completed the survey and two of them did it just partially or did not answer one or more questions. All STs who consented to participate were encouraged three times, via email, to complete the survey.

III. Personal interview. Five STs consented to participate but just two of them were able to take part in the interview.

3.8.2 Ethical considerations.

Data was collected through a variety of sources as was shown within this chapter. Before all the data were collected, following the Monash University Human Research Ethics Committee procedures, ethical approval was cleared and consent letters were obtained from participants. For detailed data instruments, see appendices A to E; the ethical approval is included in appendix F.

4 Data and Data Analysis

4.1 Introduction

This chapter first begins by introducing the TE and his background. The data from the study is then presented and grouped under particular themes that became evident in its analyses. These themes are explored using all data sources (both from the TE and his STs) and a discussion around the themes is provided. The chapter concludes by presenting a summary of the TE's PR that was captured by this study and how his STs' feedback was useful in informing his PR.

4.2 Physics Teacher Educator's Profile

The physics TE had an experienced career within the educational field. He started teaching physics full time at secondary schools in 1979, and taught continuously until 1997. In 1998 he started teaching physics method at a public university in Melbourne. He worked at the university two days a week and at a secondary school, three days a week. In 2000 he enrolled in a part time master of teaching course which was completed in 2003. His dual commitment, at a university and at a secondary school, finished in 2005 when he resigned from the Victorian education department and ceased his work in secondary school. From 2005 he held a position in the faculty of education at the same university as a casual sessional lecturer, where he taught the physics method unit and a couple of other units. He was also sometimes employed by the university as a research assistant and project coordinator. During the last two years he also held a position as a research fellow. From 2014, he currently holds a lecturer position within the faculty.

During this nearly fifteen years teaching in the physics method unit he has often considered and reflected on relevant aspects and experiences that have shaped and guided his PR. Indicative statements from the TE that show aspects of his thinking about his PR are provided below:

(a) his role as a science/physics TE,

“But, I think, my time, seven weeks, is so limited … [in which to]… unpack the course when the students are going to do that, anyway, they’re going to have to teach it, they’re going to have to open their textbooks, they’re going to have to become familiar with the content. And, you know, sink or swim, that would be their task but I think that´s their task, it´s not my task. My task is to give them some ideas about the ideas that are already in kids' heads about the content ... to give them some ... teaching strategies and ideas about how to unpack the content” [Appendix G, TE Pre unit interview, row 72-73]

(b) his main learning intentions,

“…they´ve got an understanding of what the demands on them as a teacher, would be. But also my intention is, always to focus on looking at ways of improving conceptual understanding”. [Appendix G, TE Pre unit interview, row 4]

(c) skills that are significant in teaching physics,

“…being able to ask good questions about aspects of learning…” [Appendix G, TE Pre unit interview, row 9]

“...the idea of involving students in practical work with a purpose, so that it´s actually an authentic task…” [Appendix G, TE Pre unit interview, row 9]

“...authentic assessment as well, so what is a good assessment task, which actually authentically assesses the learning objectives that you´re actually intending to do ...” [Appendix G, TE Pre unit interview, row 9]

“… reflect on what you might know and try to identify the areas that, you think, it might need to improve on. Because often, we think we know something but it’s not

until… there are some difficult questions from students …so they ask embarrassingly awkward questions…" [Appendix G, TE Pre unit interview, row 13]

(d) what is important in teaching a physics method unit, why is it important, and how, as a TE, he could improve his teaching

"I guess I'm trying to put myself into their position... what is it that... I will want to know, if I didn´t know a great deal about going out and teaching physics. So what would be some of the key things.....and I guess...that the course reflects that, I think, the things that I think...umm...would be most helpful..." [Appendix G, TE Pre unit interview, row 50]

These statements from the TE underscore key elements of his PR. It is possibly to argue that, what he sees as important, within the method unit, is determined by his beliefs and views about what teaching physics is about. It is also apparent from the statements above that how he models himself and his own teaching in the unit, is connected with what he thinks his role as a TE should be.

This section introduced background information about the TE and also some key statements that begin to show his PR. The next section presents his data by way of major themes that emerged from his statements, classroom observations and his STs.

4.3 Major Themes that Represent the Teacher Educator's Pedagogical Reasoning.

Commonalities that arose from the data were noticed and grouped together. Four major themes were evident and these were reinforced many times over through the TE's comments. These themes represent the big picture thinking that represents the TE's PR. The first theme centres around the idea that effective teaching in physics involves being able to explain the physics. The second theme is that "doing" is important. The third theme was that his STs needed to have their physics knowledge and their teaching pedagogy challenged (i.e. made them to feel uncomfortable) and the final theme was that his PR was informed by his STs' feedback.

Within the following sub-sections, those four major themes detected are supported by a significant number of quotes allowing the emergence of what underpins this physics TE's PR.

4.3.1 The teacher educator considers "explaining" as a key element in his pedagogical reasoning.

"I think one idea that underpins my teaching of physics, is that physics is about explaining or attempting to explain your observations. So, it´s about explaining a phenomenon of some sort that you observed or interacted with or experienced. And....in many ways it is looking for some very simple elegant experience where they can interact with whatever that phenomenon is that you want to talk about." [Appendix G, TE Post unit interview, row 80]

To confront traditional teaching practices, typically teacher centred and transmissive learning, he explained how he asks his students to explain a concept but then challenges their thinking, whereby their original explanation needs revisiting. The following problem is an example that he uses to test and further develop their knowledge of the content for teaching.

"[Take a] classic pendulum, which is...like a whole sphere full of water ... and the water is dripping out, and the pendulum is going backwards and forwards as the water drains out of the sphere from the bottom …I'll quickly draw it up so you've got an idea, because it's actually a nice problem… Ok, so this thing is swinging backwards and forwards, full of water, and there are little drips coming out of the bottom from the hole in the bottom, ok? And, the question is, what happens to the ... pendulum. Does the period [time taken for one whole swing from one side to the other] change as it

swings backwards and forwards? Well, most students initially look at the problem go "well, you know, "T" squared two "pi" on "l", "g" or something", has no mass in there [i.e. there is no mass in the equation used for determining a pendulum's period], pendulum don´t depend on mass, so therefore "no, they´ll be no change in the period of the pendulum swinging backwards and forwards". They usually look at it a little bit more deeply and realise that in fact the centre of mass is actually dropping [lowering], so therefore, the effective length of the pendulum is getting longer… "Oh, so if the effective length is longer, the period will get longer as well", so they go "Oh, the solution is the period will get longer" … ha-ha. Because it's gets longer for a little bit, but then, as the water drains away, the centre of mass goes back to the original point, as when it was full of water, and so it´s goes back to the same point again." [Appendix G, TE Pre unit interview, row 109]

The problem is presented to the STs and they have to be able to think about explaining it. Soon afterwards, they have to share their actual conceptual understanding of it with the rest of the class. Within this cognitive process, STs offered feedback for evaluation purposes. They understand that it helps to develop a stronger conceptual understanding of it, and they get some ideas about the purposes of teaching physics and as a process through which they can construct their own science teaching pedagogy.

"Everyone always gets this wrong because, maybe a third of the class says "no change at all", because it is not depending on mass. Two thirds say that it is important because the effective length has something to do with it, and so they're very excited about the fact that it gets longer. And then it´s one third that go "Oh yeah, but then it gets shorter again back to its original amount. So it gets longer, but then it comes back to the same". So it´s usually about thirty percent of the class that will come up with the correct solution but what's nice is that they all get the opportunity to see how each

other´s thinking is and unpick what it looks like, you know …" [Appendix G, TE Pre Unit interview, row 110]

In exploring a problem like this, STs gain a sense of what pedagogical content knowledge is and how they could apply it to their own physics classes. A provocative example and good questions are significant parts within the instructional stage of Shulman's PR model as was reflected by ST4 in their interview.

"Well, I think asking questions is important because ... it´s an active part of learning, right? If you're just sitting there …you're not extending your "so what", by asking follow-up questions. You´re not actively learning; someone is trying to pour water into your head, and ... and it just flows away, right? So I think asking questions is one sign of active learning." [Appendix H, ST4 Interview, part 1, row 14]

It was observed often in the TE's classes that he allocated enough time to present these types of lesson and that he encouraged his STs to think and explain the content. Sometimes, the problems were quite challenging for his students. Sometimes, his waiting time was longer than six seconds. That was a normal situation within his classes; he gave enough time in letting people think about their experiences and observations, and in developing their own explanations. (see class transcriptions, Appendix I).

4.3.2 "Doing things" is important in the teacher educator's pedagogical reasoning.

Teaching and learning by doing is very important in the physics TE's PR. He claims that it impacts his actions and reflections in his teaching. If something is important in learning how to teach physics then time needs to be provided to thoroughly explore it along with a hands-on experience. By "doing", he argued, STs can perceive its relevance and also examine their own comprehension. In consequence, even if they did not completely clarify their thoughts, the experience gives them the opportunity to explore their own approach and, hopefully, will guide them to further research, which is important to develop their own pedagogy and keep improving their practice.

“There would be some students [who are] confident ... There would be some students they’ll all go, "I´m not quite sure, what we would be doing today", you know, "we´ve come in here, and I´ve made a plastic balloon out of, you know, plastic bags”... Forty minutes, is a long time to spend on it, and it is. But, in fact, unless you invest some time in those things, I don´t believe they’d believe it is important. I couldn´t stand up there and say "this is a really important activity, you need to be able to develop these skills", but I'm not even prepared to spend five minutes on it.” [Appendix G, TE Pre unit interview, row 23]

The previous quote is about an experience that STs had in week two. Because secondary students’ conceptual growth can occur through experience, and to explore concepts in physics is important, the physics TE asked his STs to build a hot air balloon made out of plastic bags to clarify their thoughts about density, gravity, sinking and floating. For the TE it was not enough to explain a particular approach or experience and then back it up with theory. It was important to experience it as a learner and then reflect on it as a teacher. The activity was also revisited in the subsequent class.

“So, why was that important for them, to experience that whole practical activity… and put themselves in that position, not from the learner …, but to put themselves in the ... in the teacher role, what is it they will hope to get out of that experience if they were a teacher teaching this to other students. And so, having lived the learner role, being the learner, then they can say...hopefully reflecting on that, and seeing what the difference might be. Why it is that? Do I have some reasons behind

doing that particular activity in the first place? I think that´s really important, particularly in teacher education, to shift between the teacher and the learner, all of the time.” [Appendix G, Week 3 TE short interview, row 7]

It can be observed that the STs’ reflective experience through their transition from learners to teachers is a concern to his PR. When the TE reflects on this activity, it is not just from the TE standpoint but from their STs’ own experience and their transition to being a physics teacher too. This idea is clearly reflected when ST4 expresses:

“Yeah, so when you´re saying moments of learning, there were a couple of moments of learning. One was actually just building, … making the hot air balloon, right? And … it´s good how [TE’s name] did the candle thing, you know, like he actually heated the candle and edges of it rather than sticky tape and everything [i.e. placing two plastic bag edges together and then binding them by heating]. I wasn´t sure that it works, because carrying out the candle. How is this going to work? But it actually worked really well, and it was easy too, it was actually very easy to do ... So, I thought it was good just from the student point of view, like me just full of confidence like, "Hey, I can do this", you know, it´s just a small physical thing that I did, that actually worked well. I said "Oh, I can do this", because I don´t have a lot of confidence when it comes to prac, doing pracs [practical activities with students at school]. So it was good, it actually worked, and then making it, and then seeing the thing floating up was great … was such a visual validation of that, right.” [Appendix H, ST4 Interview, part 2, row 55]

This quote is full of expressions of excitement and validation of doing things. Therefore, the TE´s commitment to doing purposeful and engaging activities with his STs was valid and highly connected with what the students observed as relevant outcomes from this physics method unit. This idea can be observed within the survey responses too, as it can be seen in the following quote, when his STs were asked about why those skills/ideas/concepts were so important to them.

"The use of practicals in the physics unit allowed me to see pracs from both a teacher and student perspective. As a student in the class I was more engaged in these hands on prac tasks. As a pre-service teacher, I saw the learning potential of these activities and learnt how these activities can be integrated into the physics classroom." [Appendix J, Q17, Response 5]

4.3.3 The teacher educator believes "challenging" his student teachers as important in his pedagogical reasoning.

How the TE keeps his STs motivated, and how they also learn the skills to motivate their future students, seems to be a really important concern, probably a critical one. As a strategy, the TE asked them a question in a way like any year 8 student could do. Hence, STs have to think deeply about their own conceptual understanding and how they could respond, as a teacher, to this very common situation.

"We had another situation in the first semester … which was two weights, which I put down on a desk, you know. So one like that [a glass of water]… you know, and a pencil. And we went through the whole formal textbook sort of approach, drawing diagrams of weight force down, and reaction force of the table up and all of that, and they´re all feeling very bored, and ... "yeah of course, I know about this, you know, I set that a million of times … these sorts of diagrams". And then I hit them with the question "though, this is fantastic, but the table is very smart, because the table knows, how hard to push". The pen knows how... hard to push up, you know, the reaction force, you know, a certain amount. But for the really large weight, it knows to push really hard, because, it has to still over there. So my question to them was, you know, "How is it

that the table knows how hard to push?".... None of them could answer that question at all." [Appendix G, TE Pre unit interview, row 91]

The selected approach, to transform physics method content knowledge and the strategy used within the instructional stage, moves STs from a really comfortable position to a highly uncomfortable situation. From that uncomfortableness STs make efforts to track some ideas about their understanding about physics and how they might deal with that question but in the teacher role. The exercise helps them in building up their own pedagogy, and also to think deeply, not just about the content and how to deal with it (learning centred), but also about their future secondary students (learner centred). They have to be better prepared for their future as teachers.

"…he was doing a mock question that is what actually occurs in a class, you know, someone could ask the question of that, right. What if someone asks the question? … So, I think it´s about ... you know, asking the right questions, I think, even as a teacher. So, you´re thinking about the question that the students would ask in … [about] any concept, anything that you want to teach. What are the questions that you come up?" [Appendix H, ST4 Interview, part 1, row 9]

This lesson is continuously revisited by the TE. In the post unit interview, he reflected on it again and played with it to offer new alternatives to keep his own STs engaged.

"And complete silence in the room...engineers build bridges... don't know these sorts of things and no response to this question at all. And they talked, maybe half an hour of working through that before somebody has the brilliant idea that there´s some distortion in the table, and it gets this … reaction force out of the table to be able to push up, so the table, actually, didn´t make a conscious decision about this at all. And so, they want to probe it by putting some mirrors, down on the table; out front I have a laser line going across and hitting the mirror. So that...as the mirror, you know, the

whole lead into, you know, I´ll sit on the table, and you can see the deflection of the laser go up the wall or go down the wall, depending on how much the table is [bending under my weight]. And then, of course, everyone is really comfortable with the whole idea of being a distortion in the table and that the reaction force comes from the distortion.” [Appendix G, TE Post unit interview, row 63]

So he kept his STs feeling uncomfortable about their own conceptual understanding for a while. However, afterwards, he was able to demonstrate that they can come up with a solution and the stress was reduced, but keeping them thinking and reflecting. Furthermore he provided them with opportunities to make new links.

“So, they all go: "This is fantastic." … you know, "this is really good, I´ve never thought about that before”. And then was a matter of shifting at … you know, the concrete floor. Well, what happens with the concrete floor, when I put the pencil on the concrete floor? And they were all going "Oh, there´s no distortion there." And then I go "How does it know how hard to push"; and they were going "Oh, yeah, I know, it must be the same". So, there was this huge link. At first there was no link at all, because I´ve never seen the concrete floor distorted in anyway at all. But then some of them realise that actually the two of them were highly related and linked them. So that was a real breakthrough moment, for many of them, to take what is so simple, and be stumped so easily with such a simple question. You know, this is a question [that any] year 8 student can ask you, "how does the table know how hard to push? I´ve never thought of that!” So it was nice.” [Appendix G, TE Post unit interview, row 81]

There are many situations of learning arising during these moments. Some of them are triggered because STs have different backgrounds, some of them have certain knowledge and background about the concepts but others just have general knowledge about some physics content. Also, he is conscious about their different levels of sureness; some of them are confident in sharing their ideas but others do not have that confidence. However, the planned instruction has demonstrated good results and also offers solid ground to improve it, and then use it with further cohorts of STs. Furthermore, it also motivates STs to further research and offers a great opportunity in reducing their own weaknesses either, in their physics content knowledge, as well as in their actual ideas of and about physics teaching pedagogy.

“I let them go over two periods, like over two classes, so they´re feeling very uncomfortable ... for some period of time, because, I think it is important to feel uncomfortable ... it really motivates people … So rather than give them the answer straight away, I´ll say "I´ll discuss this over next week, but you will have to think about it" and there wasn´t one person in the room who didn't have to think about it, or had to go away to start Googling things to try to work out what was going on, because, they didn't have an answer ... Well, one of those skills is looking for ... cognitive dissonance ... where two things , just don't seem to match what you think. And you can create that, I think, really...is a strong motivator.” [Appendix G, TE Pre unit interview, row 93]

A core aspect, included in this physics method unit, which can be observed all over the content (physics pedagogical content knowledge, purpose of teaching physics, use of new tools for teaching, research skills, learning how to teach physics), is included in the following sentence. It explains one relevant aspect of his approach; using activities that have a simple context to challenge students’ conceptual understanding.

“So it´s about taking a simple context and looking for ways that might challenge their understanding within that simple context.” [Appendix G, TE Post unit interview, row 63]

4.3.4 How feedback impacts the teacher educator's pedagogical reasoning.

4.3.4.1 Feedback through evaluation at university.

"And then there is an evaluation, which they do online for the university, as well. And that has always consistently, been very positive. … So, I think ... it´s the humble bit about, you know, be very humble here. But the course scores very well, in terms of students ticking boxes, is typically somewhere around 4.8 out of 5. Ok, so I think … most years I´m in the top one hundred courses out of the three thousand seven hundred that are offered within the university, in terms of students giving feedback on it. I think the best I ever had was 78." [Appendix G, TE Post unit interview, row 7]

"Physics education in the secondary years B" is a highly recognised unit within the University because STs' have given high scores to it in the official units' evaluation for a number of years. STs have been recognising the connectedness between the TE´s PR with their expectations about what they like to get out of the unit.

"I´m happy, it´s one of the, you know, high scoring courses in the faculty, there´s no doubt about that." [Appendix G, TE Post unit Interview, row 9]

4.3.4.2 Feedback related with student teachers' sense of positive change.

Connectedness between what STs expect to get from the unit and what they really got from it can be observed in the following sample of the survey results. These results demonstrate that most of his STs expressed their satisfaction with the unit, and with what they got from it. This analysis includes some of the answers given by STs to a couple of significant questions (for full results see Appendix J).

Figure 3, which is shown below, expresses STs' confidence on having been connected with the lecturer in a positive manner. As a consequence of that, most of them think that they built a better understanding about what good physics teaching looks like is.

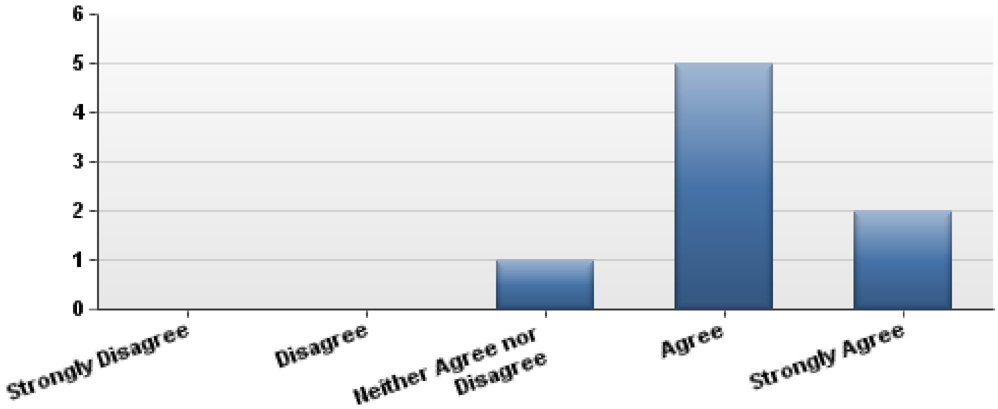


Figure 3 My approach to teaching physics has had a significant change during the unit because of the lecturer (Student teachers' response. Survey, part B statement 5)

This physics TE knows some of the factors that have been building his STs' ideas about what they think teaching physics is, before they enter his unit. He is aware about what the tendency is for them, as teachers, would be if the physics method unit did not take their previous ideas into consideration. In consequence he is aware about his STs' ideas of: learning, teaching, knowledge, conceptual understanding, among others. He has developed a good understanding about what STs think, before they take the unit, and what kind of influence they had received during their long experience as learners before they enter his teaching program. Figure 3 reflects graphically how effective this unit had been, and consequently, the lecturer's approach to teach. That effectiveness is grounded on how extensive and deep, the physics TE knows STs' experience during their schooling and even at university.

“There´s a number of students there, who I think from my impressions, would have a fairly didactic approach to teaching, very constraint sort of centred. Although they may give lip service to student centred activities, I think it´s probably going to come back to being highly teacher centred, mostly power point presentations, that sort of thing. And, that´s a tendency that comes out the fact that they´re physics students, which means they´ve seen that style of teaching model … a lot in the courses that they´ve done.” [Appendix G, TE Post unit interview, row 16]

For this physics TE, a significant objective is giving his STs an understanding of what good teaching physics is and what it looks like. In consequence, a very important aim is to offer them a variety of models, strategies and, more importantly, engage them with his learning intentions. The following three quotes represent STs’ changes in their own approach that highlight that connectedness between TE’s approach and STs’ learning in this aspect.

“Learning physics is doing physics, to understand. ´Cause a lot of the times it´s hard to misunderstand, just broad learning and reading; you have to actually experience the learning in order to fully understand. And just be aware of alternative conceptions as well.” [Appendix H, ST3 Interview, row 4]

“It was a lot of transmissive learning. But then, you know, I’m just starting to learn about pedagogy and ... it helps you to...well it helped me to, I guess, understand what kind of teacher I would’ve become. So, I think that it [pedagogical content knowledge] exists, because otherwise you wouldn´t know what kind of teacher you... you don´t just assume a way of teaching. So, I´m very into, like, collaborative learning and just ... student centred classroom, rather than the teacher just being on the board and just writing all the information.” [Appendix H, ST3 Interview, row 56]

“It´s the way that [TE’s name] conducted himself as a teacher. That´s what I want to model myself on; not necessarily the activities, because the activities could

change, and could become out-of-date, but as long as I´m able to ... to kind of be as resourceful, because [TE's name] is so resourceful, you know, pull in so many different areas. And I can take some of that, and I think that´s the bigger learning for me, rather than, you know, building a hot air balloon. If I can, you know, be as resourceful as I'd be, as committed, look to the theories, backed up with theories, backed up with examples, um...think about questions, think about interesting questions. If I can do that, you know, then I would´ve model myself on [TE's name]´s class, and I would´ve been that successful. And, I think ... I think, in some sense I have done that." [Appendix H, ST4 Interview, Part 2, row 76]

Within the online survey conducted, STs were asked: Do you feel that the lecturer and his pedagogical approach helped you to achieve these skills, ideas/concepts? There were six responses, all of them positive.

Table 3

Do you feel that the lecturer and his pedagogical approach helped you to achieve these skills, ideas/concepts?

Yes the subject was well structured with a focus on how to teach the content, rather than the content itself.
Yes, there were a wide range of activities that were shown that could be implemented in the classroom as well as how to address and rectify students' alternate conceptions.
Yes
Yes
Yes, definitely.
Yes.

[Appendix J, Survey results, Q18]

In summary, many of his STs have experienced a significant change in their approach to teaching physics. Their feedback suggests that the TE's PR makes sense to them. Clearly their opinion, after two teaching rounds of five weeks each (secondary school based teaching practice) and after a long experience as learners, provided valuable and reliable data. That contributed to validate the TE´s expression, perceptions and interpretations about his own PR.

4.3.4.3 Feedback related with student teachers' learning how to teach physics

The physics TE's STs state clearly that they have been learning how to teach physics, therefore, they are now better prepared to do so.

"... but, I guess I would've a lot more ... more experience in that sense, but it´s still, obviously very new, I was very nervous but, better than I was before. So, after the unit … experiencing, the different classrooms, the different environments, the different approaches, strategies to use, you kind of have... you´re equipped better or more better equipped. But, I could be equipped better still. But I guess it just comes [down] to the time..." [Appendix H, ST3 Interview, row 94]

Figure 4, which is shown below, expresses STs' confidence in what had been learnt in "how to teach physics" throughout the unit. In that sense, it is evidence of their confidence of being able to develop their own pedagogy during the unit.

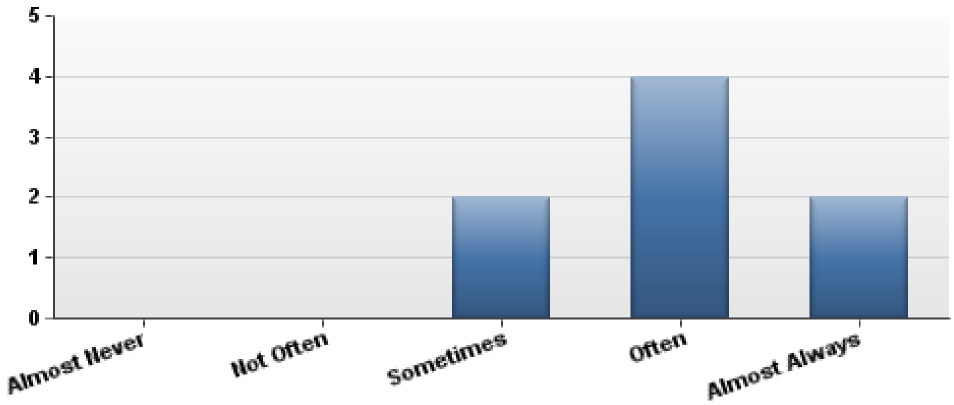


Figure 4 During the unit I learnt how to teach physics (Student teachers' responses. Survey, part B statement 6)

The following quote, concordantly with the previous interpretation, gave validity to that interpretation in a clearer manner.

"But at the end of the year, I feel more confident about my content knowledge because of my round of classes. And [TE's name], you know gave me more confidence in just being in the classroom." [Appendix H, ST4 Interview, row 42]

On the other hand, within the pre unit interview the TE was asked about how he recognises that his actual STs are learning how to teach physics; his answer was that this focused on two points:

- *"… immediate feedback that I'll get within classes, so, the types of discussions that I´ll have …"* [Appendix G, TE Pre unit interview, row 124]
- *"… and of course the reading assessment tasks, as well. So, they'll do the assignments, which unpick their thinking ..."* [Appendix G, TE Pre unit interview, row 127]

However the feedback is not just used to recognise their learning; it is used for rigorous assessment purposes.

"... There are students who are no longer in this semester because, their thinking was erratic, unclear and not very professional, and so they've failed those assessment tasks, and they haven´t been able to go on to complete the course. So, and there is a number of them who ... do not meet the criteria, I guess. But that´s, you know, as in terms of all assessment fairly objective, ok. There are still rubrics up there that can assess the work, but it still comes down to, I guess, a bit of a good feeling about, whether or not, someone's actually meetings the rubric or not … Is this person someone I could recommend as a physics teacher?" [Appendix G, TE Pre unit interview, row 127]

The TE clearly separates two aspects of his PR - his own perceptions about how successful he thinks the unit was, and his STs' thoughts on perceiving how successfully their expectations about the unit were met. That clear idea could help in articulating the unit and also represent an additional dimension investigated within the TE's PR, as was shown in chapter 3 (see Figure 1). The next quote expresses how he captures what his STs wanted to get from the unit and are tied in with his STs' views about it, as was articulated previously.

"They expect that they're going to walk away with a better understanding of how to teach physics, they expect that they're going to get a range of resources and ideas, they expect to be able to have some underpinning ideas that´s going to focus how they're going to do and present and do all of that teaching ... within that particular subject." [Appendix G, TE Post unit interview, row 13]

The data collected from STs provide insightful thinking, which seem to be closely connected with what the TE manifests when exploring his own PR.

4.4 Chapter Summary

The following table summarises the TE´s perceptions of his PR. It can be observed that they reflect on his comprehension about what the physics method unit was about. However they also represent expressions of his evaluation and reflection because they were highly connected with what his STs wanted to get from it. Consequently, all stages of Shulman's (1987) model are interconnected when the TE explains his own PR. The articulation of it, within the TE's PR, is starting to be made explicit and is explored in the next chapter.

Table 4

Representations of the Teacher Educator's Pedagogical Reasoning.

1. The TE considers explaining as a key element in his PR.
The answer is not that important. What are critical are students' approach and their thinking behind their approach.
The approaches, and thinking behind that, are critical in teaching and learning physics.
To gain experience, STs were encouraged to explain their thoughts about conceptual and experimental physics problems.
STs were encouraged to share their knowledge, their skills and their reflections.
Explore why students think the way they did.
Explore and use simple context to challenge students' preconceptions.
Explore and be able to make good questions.
Give students enough time to think and also to explain their thoughts.
STs were encouraged to reflect on their solutions and how to present an argument.

Table 4

Representations of the Teacher Educator's Pedagogical Reasoning (continuing).

2. "Doing things", an expression of the TE's PR.
Invest time with STs by doing activities could change STs' beliefs about what good teaching physics looks like.
Create ways to get students interested in physics.
There is no point in doing things without a plan. They have to be done on behalf of learning intentions.
STs have to play the role of students to know how they will be driven and manage the activities.
STs will do things differently. They have to deal with their own approach and build up their own pedagogy.
Teaching physics is about doing and learning about their experience during practice.
Being able to make good questions is a relevant skill to develop. But how to develop it is by experiencing, doing and taking risks within their classes.
STs have to play the role of teacher and analyse what is relevant, why that is important, and how they will do it. There is no other way to detect if their teaching was successful but by observing their own students "doing" (i.e. hands on).

Table 4

Representations of the Teacher Educator's Pedagogical Reasoning (continuing).

3. The TE believes that "challenging" his STs as important in his PR.
Uncomfortableness motivates STs to think and research their own weaknesses, both with physics concepts and physics teaching pedagogy
STs think that they have to get the answer right but they have to deal with the idea that there is no right answer.
It is about repetitively questioning their own knowledge and their own practice as teachers.
Teachers are not going to grow if they do not take risks and explore what they know and be aware about what they do not yet know.
Uncomfortable exemplary discussions. About practical work; does it serve any purpose or just create confusion? About theory in education; does "pedagogical content knowledge" exist?
The student-centred approach in teaching opens up a place for uncomfortable questions from students.
Linked with the concept of cognitive dissonance.
It is a cyclic process where all become comfortable after a while.
Place enough time to think and to express their ideas is a not common, but very fruitful, teaching practice.

Table 4

Representations of the Teacher Educator's Pedagogical Reasoning (continuing).

4. How feedback impacts the TE's PR.
What a TE tries to hit within a unit and how successfully STs think those intentions were hit, are totally different things.
The evaluation of the unit has to be done from two stand points; what the teacher thinks the students get of the unit, and what the students think they get from the unit.
Be aware about STs' experience as learners during their schooling time and as learners in physics units at university.
Journals and feedback, and also looking at people's eyes give hints about whether or not things are going successfully.
Immediate feedback, as well as assessment tasks, provides enough data for STs´ evaluation and unit evaluation.
While journal entries (written assessment tasks) are more conceived feedback, in class reflections get a sense of "what´s going on".
Good assessment tasks are needed to authentically assess the learning objectives.
Getting feedback is not just for learning purposes and recognising them, but also for assessing them and detecting if they will be adequate physics teachers.

5 Discussion of the Teacher Educator’s Pedagogical Reasoning and How it Relates to Shulman’s Model

This chapter includes three sections. Within the first one, the physics teacher educator’s (TE’s) principles and beliefs that shaped and guided him through his pedagogical reasoning (PR) are discussed. In other words, what does it mean for the physics TE to teach and learn within the physics method unit context. The second section explores the TE’s PR in action. The discussion there, is mainly concentrated on the first three stages of Shulman’s (1987) model: comprehension, transformation and instruction. What the TE conceives as content knowledge within his method unit seems to be enlightened by his principles and beliefs (as discussed in the first section). The last section, tried to capture how the TE uses student teachers’ (STs’) feedback to explore to what extent they learnt about teaching physics, as well as to what extent they are developing their own PR. Unceasing encouragement of ST’s feedback played a key role in his PR. In this last discussion, the other three Shulman’s model stages; evaluation, reflection and new comprehension were used as a helpful framework.

5.1 Principles and Beliefs -understanding the Teacher Educator’s Pedagogical Reasoning

Why the TE made particular pedagogical choices when teaching particular content and how he supported his STs in developing their own PR the way he did, is guided by his principles and beliefs. Within this study, a number of indicators were observed that showed a thoroughly updated, skilled, resourceful, engaging, student centred, and expert physics TE (evidence of this is presented in this chapter and also in chapter 4). He was proud of the feedback officially given of his physics method unit that place his unit “*…in the top one hundred out of three thousand seven hundred units offered within the university in terms of students giving feedback on it.”* [Appendix G, TE Post unit Interview, row 7]

Also, he valorises STs' feedback because he believes that it is a significant point of view to get the unit connected to what his STs will need in their practice (as STs and then as teachers). This after-course evaluation, which gave a high score to this physics method unit, represents his STs' views, far from any judgment that could involve the TE or the unit.

"I think it´s great, I think it´s perfect. It's a perfect level. When I came into the course I was a bit nervous about my content knowledge. You know, not having done physics for a long time … But no, it was very hands on … it was very engaging. I think he engages the whole class, it was group work, it was a good mixture, so you really blended; kind of him teaching vs us doing, vs us questioning, vs us discussing, vs us comparing … " [Appendix H, ST4 Interview, part 2, row 32]

The physics TE was aware of the uneven content knowledge level and he believes that it is not that relevant because they will be able to unpack the content. That is exactly what is expressed in the next quote; a ST's concern before the unit, and what she/he got from the unit.

"For instance, the thing that always sticks in my mind and I wrote this in the reflection as well, was ... When he demonstrated... the curvature of the table [when we explored the reaction force] by standing on it, and … the reflected laser point actually moves down a little on the wall … That one sticks in my mind and I think that captures... so many aspects of teaching. I think it captures the modelling prac, you know, the prac is actually modelling the thing, but it also captures his commitment, because he´s committed to the thing, he´s standing on the table, you know, to show us this... his whole body, it all brings commitment to the teaching. " [Appendix H, ST4 Interview, part 1, row 4]

It can be observed that, learning theories with a direct connection to practice was captured by this ST. This kind of teaching practice, within teacher education is not common. TEs, generally, have a disposition to not include, in their own teaching practice, any learning theories of those that they usually teach to their own STs (Lunenberg et al., 2007). Then, the previous quote expresses that the physics TE is more likely to be in the small group of exceptions who not just teach new learning theories and approaches to them but include those in their own teaching practice. It represents his PR; his comprehension of physics teaching pedagogies, the first stage of Shulman's (1987) PR model.

The physics TE is observed as genuinely student centred because most of his arguments and thoughts are based on STs' feedback. He expresses, in a clear manner, how he builds up his method unit when planning and reflecting on what and how he intends to teach. He explained: "*I guess I'm trying to put myself into their position."* [Appendix G, TE Pre unit interview, row 50].

"… be critical of what you know; reflect on what you might know and try to identify the areas that, you think, you might need to improve on. Because often, we think we know something, but it is not until there are some difficult questions from students, who ... often, you know, don´t know very much about it, so they ask embarrassingly awkward questions, sometimes, because they don´t know enough to, actually, ask what we think is a sensible question." [Appendix G, TE Pre unit interview, row 13].

Getting feedback from students plays a significant role, and also that feedback helps STs to see their weaknesses. Giving impetus to students' learning (Shulman, 1986) and taking care of STs' expressions and actions in trying to help them to find their own pedagogy (Freese, 2006), are two aspects clearly articulated in his comprehension about this method unit. Getting feedback about how STs are coping in their transition from learners to reflexive teachers underpins his principles and beliefs about how to construct, deliver and revisit his method unit. They constitute key aspects on his PR.

" … I taught in high school and taught these courses at the same time, for about six years, and I think that was, probably the best of both worlds for the students. Because they got someone who was current in terms of teaching … and can come in and share all the experience I had yesterday, you know, about teaching things. So, I think that´s the best world…" [Appendix G, TE Pre unit interview, row 51].

As well as getting feedback, currency in teaching physics occupies a relevant place. In consequence when he planned this physics method unit, after he ceased his work in secondary school, he worked out how to keep this currency about teaching physics at secondary schools, but without deviating the unit from its key aspects.

"So, I´ll try to use the other teacher coming in to provide some of that currency, in terms of resources and, you know … the best practice that works … But, there´s no point having a magic bunch of resources and no plan on how to unpack them, or what´s important... what do you emphasise out of those resources... I think that´s where the key underlying objective of teaching physics comes from. You have to develop some sort of plan; you have to have a plan on behalf of how learning occurs, you have to have a plan on behalf about... what´s important, in terms of the big picture, ... because without that all that you got is an internet full of resources and no way of deciding what´s good and what´s bad, because there is a lot of bad stuff out there as well." [Appendix G, TE Pre unit interview, row 52].

The physics TE's PR expressed an open analysis of his choices; most of the time he knew why and how and when to present a workshop, prac work, an example of a pedagogical theory in science teaching and so on. So almost none of the problems faced by TEs when trying to link their practice with theory in the framework detailed by Lunenberg et al. (2007) can be observed. He did not care how deep his STs go through an experience - usually he was seeking his STs' comprehension, and more importantly, he was able to explain his approach to them and was keen to revisit his teaching. He opens it up and clarifies his learning intentions with his STs. This approach is observed in the next quote when he invited his STs to analyse and criticise his previous class.

"Ok ... let´s start with ... the balloon construction. [What is the] purpose of doing something like that ... Why might have, actually, spent, what was it, you know, forty five minutes or something of a class. Time is precious here. Why would I allocate forty five minutes to something like ... a balloon construction task do you think?" [Appendix I, Week 3 class transcription, TE, row 1].

These kinds of activities were included to facilitate, and explicitly reveal STs' difficulties, problems and worries within their transition from being a learner to being a teacher. A friendly environment is offered to explore their actual knowledge, skills, and pedagogy, to think about it. His comprehension about what this physics method unit is about, why the approaches selected are significant for his STs, and how to deliver those, is articulated within the other stages of his PR.

5.2 The Transformation and Instruction Stages of the Physics Teacher Educator's Pedagogical Reasoning

Table 4, in the previous chapter, includes a summary of what this physics TE conceived as content knowledge within his physics method unit. What will be taught and the related dimensions and related topics (Shulman, 1987) are expressed, in a precise manner, in the next quote. This is an expression of what should be included in a physics method unit:

"My task is to give them some ideas about the ideas that are already in kids' heads about the content ... to give them some teaching strategies, and ideas about

how to unpack the content .... I don't spend time focusing on the content, because, it will be, I think, a complete waste of my time and, actually, waste of their time too. Because they're going to unpack the content anyway ... They're going to have to do it, the night before, you know, it's usually where that happens. "You´re going to look at it the night before you have to teach it", and so, all of them come back, I think, they´re a bit devastated when I said that, initially they all go "but I thought you're going to spend time looking at how, you know, to teach momentum or motion or something like that". And, although we might spend some time looking at some pracs, or some of those discussions problems might focus on these things ... they come back from the teaching round, though, appreciating that, in fact, actually..."I can do that", "I can spend my time on the content", "Content is not such a big issue that I thought it was going to be", "Now, tell me why I need to teach it, and how I can teach it, not what I have to teach"". [Appendix G, TE Pre unit interview, row 73].

This quote highlighted the TE's comprehension about what are STs´ real issues and what are apparent. He makes visible his comprehension and how connected he is with his STs because he knows they would be able to handle physics content knowledge. Also, it is possible to observe his expertise within the instruction stage of Shulman's model, which includes creating the appropriate environment to address students' issues. That was outlined within the strategy of comfortableness vs uncomfortableness as analysed in the previous chapter. Furthermore, Nilsson's (2009) demand on transformation of content, as something challenging but accessible to students, is visible in this physics TE's PR.

" … In many ways it is looking for some very simple elegant experience where they can interact with whatever that phenomenon needs that you want to talk about. So, if you look into experience something to do with forces, then you need only a very simple context, in which to be able to discuss that. It doesn´t need to be overly

complex. In fact, complexity doesn´t help, in terms of analysing the understanding because the understanding is usually fairly simple." [Appendix G, TE Post unit interview, row 80]

John (2002), in exploring TEs' subject matter images, highlighted their simplicity in contrast with how their STs saw it - as something complex and difficult to understand. Those TEs thought that complexities are about pedagogy, but not about subject matter concepts, ideas and/or models. It is possible to observe the same argument within this study and also a step forward in assisting STs' ideas about subject matter complexity.

"So, I think we have to look at highly creative and engaging ways of getting kids more interested in [learning] physics, and often all that means is doing things, I think, a bit differently. So we look at something like the... balloon activity this morning which was a very practical focused activity ... And, I know that even though that´s a forty minute exercise, they will be some of the students that will use that, or a variation of that, in some way to develop something that might be a bit more engaging in their classes. So, it's a sort of a great creating wave … doing an activity in some sense. And I guess I'll keep those sorts of things because the feedback that I have from other teachers when I go back out, or students I have like five or six or ten years ago are going "I´m still doing this", you know, … the numbers of that the kids are really interested and excited in doing things like that." [Appendix G, TE Pre unit, row 18]

While exploring this physics TE's PR, most of the dilemmas discussed, within interviews and observations during classes, dealt with STs' thinking about their subject matter knowledge and their approach to what it means to teach and learn. Certainly STs were active participants. The TE also encourages them to explore what is behind the concept or the experience by doing it. In that way, they will be able to feel what their own students will experience. Furthermore the TE was trying to inspire confidence in them. By active participation he enables them to capture and explain their own pedagogical approach. That gave these STs an opportunity to experience theoretical and practical knowledge about learning and learning how to teach. Similarly, as with John's (2002) study on TEs' experience, the physics TE was very enthusiastic in using their own classes as a model. That provides opportunities to his STs to evaluate their knowledge and approach to teach while they were doing and experiencing a lesson planned for their exploration, research, and further analysis. The physics TE explained clearly his view about this topic. It is not simply to encourage STs to do something; a TE plays a role that enable STs to follow him/her as a model. Teaching physics, as well as learning how to teach physics, is about doing things.

"One of the studies that [two TEs] have been doing here have been looking at teacher burnout. It´s huge, so the department [Education Department of Victoria] is saying something like 5% or 3% of teachers leave the profession, and the real evidence is it comes through at 50% leaving the profession within the first ten years; that´s a huge number. So, here I am … training teachers and half of them will be gone in five years or something. Is that right? Or ten years ...I think it´s really important to be optimistic about what the profession is capable of doing because it´s hard work, it's really hard work, it´s not rewarded, it´s not paid well, there´s a whole lot of things that stack up on the negative side." [Appendix G, TE, week 10 after class interview, row 16]

Early development of reflective teaching, such as critical thinking about issues within STs' practice, is perceived as a vital factor to construct STs´ own pedagogy (Loughran, 2006; Nielsen et al., 2010; Nilsson, 2009; Peterson & Treagust, 1995; Sánchez & Llinares, 2003). However, if STs are unable to capture why they are not as fruitful as they would like to be with their learning intentions that could lead them to a feeling of failure. A cyclic process where novice teachers are likely to improve a little bit every class could be helpful to release that overwhelming feeling. In that sense, a bit of attention has to be paid to STs' feelings, worries, and feedback about that in order to not push them into an uncomfortable position with not enough tools and skills to deal with it. The physics TE is attentive to his STs' feelings, within each workshop as well as within their practice. He is aware about how difficult it could be being a teacher, and how difficult it is to keep going in the profession.

5.3 Relevance of Student Teacher's Feedback within the Teacher Educator's Pedagogical Reasoning.

"...I hear other people go "what are you doing? You know, I would never tackle it like that". So, the tendency is just to avoid that situation all together. So, I think it´s better that they get uncomfortable, and you can see their uncomfortableness, you know, they are moving around going "How are we going to do this?" [Appendix G, TE, week 11 after class interview, row 21]

Within Shulman's (1987) PR and action model, getting feedback from students to gain evidence on how deeply and widely they attained a conceptual understanding is relevant in the evaluation stage. Being attentive to any ST's deviation from delivered concepts and to their reflection on those, as a method of detecting misconceptions, is important at this stage too (Nilsson, 2009). A relevant tool recurrently used, by the physics TE, is to place his STs into an intriguing environment. That strategy offers an opportunity to challenge STs' ideas, which usually gets them into an uncomfortable position. A similar idea, was a usual teaching strategy used by TEs in John's (2002) study; they tend to place their STs in challenging positions. By producing dissonance within STs' knowledge and pedagogy enables them to question their own ideas about a specific concept, and also about their pedagogical approach.

"I´m being involved in many courses here, where the learning intentions, you know, look fantastic, but, in fact the feedback from the students is that, actually, this severely misses the mark, in terms of, you know, what they think they're going to get

out of the course, and what they thought they want to get out of the course - two different things. So, I think there is, in this case, quite a good marriage between, what I think they'll be getting out the course, and what they hope to get out of the course. They expect that they're going to walk away with a better understanding of how to teach physics, they expect that they're going to get a range of resources and ideas, they expect to be able to have some underpinning ideas that´s going to focus what they're going to do, and present, and do all of that teaching ... within that particular subject." [Appendix G, TE Post unit interview, row 13]

At the next stage those evaluations should be linked to what happened when teaching, how the planning helped to reduce expected deviation, and how changes could be introduced to deal with new dilemmas and unexpected approaches. An important aim, which gives direction to his unit are STs' expectations about the course. However, those beliefs, connected with STs' understanding about what teaching physics looks like and how they will be able to do it, are helpful but with limitations and cannot be taken as just something similar to a concept. It is about being able to build up their science teaching pedagogy. In Shulman's (1987) view, the fourth stage, evaluation, is tied to getting feedback, however, for the physics TE it is also relevant to give his STs appropriate and meaningful feedback too. It is a critical aspect as it could be noted in the previous quote.

"Probably the journal entries are more powerful ... So your question prompts me to think about that, and that probably ... underlines their importance, actually … maybe they´re more important than I thought because they, actually, are informing my teaching and allowed me to make decisions about changes I might need to make on the way." [Appendix G, TE Post unit interview, row 32]

Feedback obtained from STs is a crucial element in this physics TE's PR. Moreover, the written assignments have the power to inform his teaching and enable him to gain new comprehension and keep improving this successful physics method unit.

5.4 Overall Discussion.

Within this interpretative phenomenological analysis (IPA) about exploring how a physics TE expresses, perceives and reflects on his PR, and to what extent it is connected with his STs, the more extended data and reflections are related to feedback. However it is not just about getting feedback from STs, and how they behave, cope with their worries during the unit, or learn how to teach physics (TE's evaluation); it includes how that feedback helps the TE to arrive at a new comprehension (TE's comprehension). It is really interesting that STs arrived to the unit with a set of expectations about what they would like to get out from the course because of their extended experience as learners. Early within the unit, the TE confronts their beliefs and views about what it entails to teach physics by doing; he gives them the experience of what it means, and what his teaching approach looks like. Also his STs experienced, within the classroom, new theories of learning, what does conceptual understanding mean and they did this through experiencing it themselves. What is important, why is it important and how a particular physics' concept could be introduced and capture students' attention are included as standard in the TE's practice (TE´s transformation and instruction).

The TE also tried to introduce new learning theories but not just by explaining, or by giving positive and negative arguments, but by doing and, after that, by trying to explain or attempting to explain the results that this new approach makes visible. In doing that, usually STs observed and argued from the learner perspective when they look into what they did, however the TE encouraged them to look at it from the teacher's perspective (TE's instruction). Not all of the experiences were successful, however, within his beliefs and views it is not possible to argue about taking risks if he, as a TE, does not take risks (TE’s reflection).

“Well, let me tell you about the disasters that I’ve had. ... I think I’ve had my fair share of disasters in terms of, you know, trying to do … something, an idea or an approach and trialling that out … and it just doesn´t go any way you were hoping that it might go. So, students don´t find that it´s engaging ... So, there has been plenty of those experiences over the years ... I guess drawing on the journals, and the feedback in the classes, and looking at the people´s eyes when they´re doing those things; that gives you some hint that, whether or not, that´s going successfully”. [Appendix G, TE Post unit interview, row 89]

His STs, overall, had a fruitful experience and their feedback was very useful to the TE. The TE used this feedback in redefining and developing his PR in an ever changing cycle. Not only was this useful for him but his STs reported that they thought more deeply about their own practice in ways they felt gave them good pedagogical modelling and helped them develop their own PR.

6 Conclusions

The main aim of this chapter is to provide insights about what were the main findings from this study, the supporting contentions for them, and its limitations. How the physics teacher educator (TE) perceives and expresses his pedagogical reasoning (PR) can be grasped through what is relevant for him to build up the physics method unit. The inner ideas of his PR can be observed in the physics TE's beliefs and views; they can be seen as its foundations. When he was teaching how to teach physics, he not just enacts those beliefs and views, but gives support to his PR and actions. In addition that provides, to his student teachers (STs), a first person experience about what it means to learn physics and teach physics. Two major ideas underpins his *comprehension* about teaching and learning how to teach physics; teaching physics is about doing, and teaching and learning physics is about explaining or attempting to explain your observations (*transformation*). What attuned his PR and actions and also to keep the unit updated to his STs' expectations about the course was the feedback. Feedback from both sides, from STs to him, and from him to his STs, played a key role within his development of a "wisdom of practice" (Shulman, 1987, p. 11). STs' feedback, during the lessons and through their assignments, informs his teaching and provides the insight (*reflection and evaluation*) to arrive at *new comprehension*. STs' perception of what they want to get out from the physics method unit is also significant. However, being aware that their expectations about the unit are highly connected with their previous experience as learners, allows the physics TE to responsively confront their conceptions about what good physics teaching looks like, and what demands for them as a teacher might be (*transformation and instruction*). STs' perceptions of learning about both, physics and how to teach physics, is also relevant to keep his STs highly connected to good physics teaching, and also to maintain their engagement with it. Consequently, his beliefs and views about what is relevant within his physics method unit are dynamically updated – never static.

6.1 Physics (and Teaching How to Teach Physics) is about "Doing" and Attempting to Explain your Observations.

The physics TE's beliefs and views are expressed through his teaching and through his PR. What is important within the method unit is determined by the TE's beliefs about what good physics teaching is about. How far his comprehension about physics teaching goes is moderated by what he thinks his role as a science TE should be. How deep and how much intensity he gives to each lesson relies on his main learning intentions and to what extent, he perceived, they are important in building up STs' skills to teach physics. In a sense, his actions and PR could be seen as a consequent action based on his beliefs and views as a TE.

It can be frequently observed within the unit, that most of his teaching is about doing things, and trying to explain or attempting to explain some given phenomenon. That was observed within practical activities, when his STs took the role of learners, or when attempting to analyse the purpose of designing a particular experience, when they were encouraged to take the role of teachers. STs were usually invited to:

- Go through the experience in the role of learners to recognise their own weaknesses; sometimes in regard to the content and sometimes in regard to their pedagogical approach.
- Go through the experience in the role of teacher, to be able to build up their own science teaching pedagogy.

Within those experiences his STs can observe his approach and their classmates' approach to the concept, whatever it is, from the learner or the teacher perspective. Then they will be able to link their own apprenticeship with learning theories and practice by doing. Evaluation and reflection is also part of the workshops, therefore STs experienced and dealt with approaches to develop their PR.

6.2 The Relevance of Feedback

Getting feedback is a key aspect within the physics TE's PR. What the TE thinks his STs need to get out of the course and what they expect to get from the course have to be connected. STs' worries, expectations and motivations play a key role in how they build up their teaching physics' pedagogy. Even though there was evidence about a strong connection between this physics TE and his STs, his PR is continually encouraging him to keep the unit updated and connected to what his STs will need in the following years. STs need to develop their science/physics pedagogy. Most of the STs demonstrate enthusiasm for following the role model represented by the TE. The data collected from STs describe a logical and meaningful experience within this physics method unit and their TE.

Exploring and confronting ST's beliefs and preconceptions (as learners and as teachers) is an experience repeatedly observed within the physics TE's classroom. His beliefs and views about teaching physics and about science teaching pedagogy, and what he values the most to build up his physics method unit shaped and guided his PR.

6.3 Implications and Further Research

Exploring a TE's PR is an individual experience. It cannot be extended or generalised to any other TE. However a TE or a teacher could make sense when reading this thesis and connect it with their own approach to teaching. In that sense it could contribute to the construction of their own science teaching "wisdom of practice" (Shulman, 1987, p. 11). The findings within this study echoes Darling-Hammond's (2006) claim on better support for STs learning within programmes that enact their approach to teaching as "learning centered" (p. 7) and "learner centered" (p. 8). Then, an approach like this could provide an opportunity to enlighten some of the shared concerns within a community of teachers or TEs.

Even though the physics TE's PR is highly connected with his STs' perceptions, a further step in exploring STs' teaching and actions could provide another approach. Exploring and observing to what extent STs' science teaching pedagogy expresses a connection to what was taught within the method unit in their actual practice, might allow a deeper comprehension.

STs' feedback is relevant in keeping current and updating a method unit. But also feedback given to STs by the TE has paramount importance too. Consequently, what STs get from TE´s feedback, what they perceive as meaningful feedback, and what they perceive as trivial or unimportance, is also a pertinent research question that might need further exploration.

6.4 Final Conclusion

Exploring a physics TE's PR helps to reveal some of his "wisdom of practice" (Shulman, 1987, p. 11) and interpretative phenomenological analysis (IPA) provides a good framework. Theories about physics teaching (pedagogical content knowledge, nature of science, modelling concepts, conceptual change, among others) and about teaching and teacher education (role model, risk taking, science pedagogy, shift roles learner – teacher, express his pedagogy, being aware about STs' worries and beliefs, among others) were enacted in every lesson. There can be observed a connection between what the ST's, at the end of the unit, wanted to get out of the course and the physics TE's learning intentions. All of these are instances that portray the TE's PR quite strongly.

To the physics TE, PR is not a rigid, cyclic structure of following a step by step approach. It is a framework to understand, see, and clarify each one teaching approach and science teaching pedagogy. For instance, even though critical events and lessons were carefully planned, sometimes they also were updated/changed during the lesson. Sometimes the physics TE plays the role of the teacher and leaves the students playing the role of learners to explore a particular concept or problem. This teaching approach enables his STs to develop an idea about what good teaching physics looks like. Then he encourages his STs to play the role of teachers and explore problems, advantages, disadvantages, of that particular situation. Usually, after that, he presents his teaching approach and pedagogy in an explicit manner, so his STs can observe and, afterwards, explain what it is important, why is important and how they can improve their own pedagogy.

Research on TEs is a field which is growing and expanding. IPA methodology offers a framework on which to draw TEs' perspectives, views and beliefs about their practice. Shulman´s (1987) model provided a frame to show the cyclic nature of how this TE's PR was constantly evolving. In actual fact, there is not just one cycle occurring between the Shulman's models, but many, some within larger cycles and some that draw on parts of cycles that informs others. In this way, this study has shown that a TE's PR is a complex myriad of cycles of various sizes informing and influencing each other in interlinking ways. PR is therefore a difficult concept to fully explore. What this research has done is to show that main aspects of a TE's PR that seem to be overarching factors can in fact be made explicit. And by making it explicit to his STs, they feel that they have a more informed way of developing their own pedagogical reasoning, in preparation for the classroom.

References

Anderman, E.M., Sinatra, G.M., & Gray, D.L. (2012). The challenges of teaching and learning about science in the twenty-first century: Exploring the abilities and constraints of adolescent learners. *Studies in Science Education, 48*(1), 89-117. doi: 10.1080/03057267.2012.655038

Berry, A. (2009). Professional self-understanding as expertise in teaching about teaching. *Teachers and Teaching, 15*(2), 305-318. doi: 10.1080/13540600902875365

Berry, A., & Van Driel, J.H. (2013). Teaching about teaching science: Aims, strategies, and backgrounds of science teacher educators. *Journal of Teacher Education, 64*(2), 117-128. doi: 10.1177/0022487112466266

Brass, C., Gunstone, R., & Fensham, P. (2003). Quality learning of physics: Conceptions held by high school and university teachers. *Research in Science Education, 33*(2), 245-271. doi: 10.1023/A:1025038314119

Bullock, S. (2012a). Exploring the intersections of self-study, science teaching, and science teacher education. In S. M. Bullock & T. Russell (Eds.), *Self-studies of science teacher education practices* (Vol. 12, pp. 1-8): Springer Netherlands.

Bullock, S. (2012b). Learning to teach physics teachers: Developing a distinct pedagogy of teacher education. In S. M. Bullock & T. Russell (Eds.), *Self-studies of science teacher education practices* (Vol. 12, pp. 103-120): Springer Netherlands.

Chastko, A.M. (1993). Field experiences in secondary teacher education: Qualitative differences and curriculum change. *Teaching and Teacher Education, 9*(2), 169-181. doi: http://dx.doi.org/10.1016/0742-051X(93)90052-I

Darling-Hammond, L. (2006). *Powerful teacher education* (1st ed.). San Francisco: Jossey-Bass.

Der Valk, T.V., & Broekman, H. (1999). The lesson preparation method: A way of investigating pre-service teachers' pedagogical content knowledge. *European Journal of Teacher Education, 22*(1), 11-22. doi: 10.1080/0261976990220102

Freese, A.R. (2006). Reframing one's teaching: Discovering our teacher selves through reflection and inquiry. *Teaching and Teacher Education, 22*(1), 100-119. doi: http://dx.doi.org/10.1016/j.tate.2005.07.003

Gallagher, S. (2012). *Phenomenology* (S. Gallagher Ed. 1st ed.). UK: Palgrave Macmillan.

Geddis, A.N., & Wood, E. (1997). Transforming subject matter and managing dilemmas: A case study in teacher education. *Teaching and Teacher Education, 13*(6), 611-626. doi: http://dx.doi.org/10.1016/S0742-051X(97)80004-2

Giles, D., Smythe, E., & Spence, D. (2012). Exploring relationships in education: A phenomenological inquiry. *Australian Journal of Adult Learning, 52*, 214+.

Giorgi, A., & Giorgi, B. (2008). Phenomenology. In J. A. Smith (Ed.), *Qualitative psychology : A practical guide to research methods* (2nd ed., pp. 26-52). London: SAGE Publications Ltd.

Hellsten, L.-a.M., Prytula, M.P., Ebanks, A., & Lai, H. (2009). Teacher induction: Exploring beginning teacher mentorship. *Canadian Journal of Education, 32*(4), 703-733.

Herman, W.E. (1998). Promoting pedagogical reasoning as preservice teachers analyze case vignettes. *Journal of Teacher Education, 49*(5), 391-397. doi: 10.1177/0022487198049005009

Höttecke, D., Henke, A., & Riess, F. (2012). Implementing history and philosophy in science teaching: Strategies, methods, results and experiences from the european hipst project. *Science & Education, 21*(9), 1233-1261. doi: 10.1007/s11191-010-9330-3

James, M.C., & Scharmann, L.C. (2007). Using analogies to improve the teaching performance of preservice teachers. *Journal of Research in Science Teaching, 44*(4), 565-585. doi: 10.1002/tea.20167

Jasman, A., & McIlveen, P. (2011). Educating for the future and complexity. *On the Horizon, 19*(2), 118-126. doi: http://dx.doi.org/10.1108/10748121111138317

John, P.D. (2002). The teacher educator's experience: Case studies of practical professional knowledge. *Teaching and Teacher Education, 18*(3), 323-341. doi: http://dx.doi.org/10.1016/S0742-051X(01)00072-5

Kindi, V. (2005). Should science teaching involve the history of science? An assessment of kuhn’s view. *Science & Education, 14*(7-8), 721-731. doi: 10.1007/s11191-004-7344-4

Loughran, J. (2006). *Developing a pedagogy of teacher education : Understanding teaching and learning about teaching*. London: Routledge, Taylor & Francis Group.

Loughran, J. (2010). *What expert teachers do : Enhancing professional knowledge for classroom practice* (1st ed.). Crows Nest NSW, Australia: Allen & Unwin.

Lunenberg, M., Korthagen, F., & Swennen, A. (2007). The teacher educator as a role model. *Teaching and Teacher Education, 23*(5), 586-601. doi: http://dx.doi.org/10.1016/j.tate.2006.11.001

Mercier, J. (2012). From laboratory to authentic contexts: Two studies of pedagogical reasoning across four levels of expertise. *World Journal of Education, 2*(4), 2-n/a.

Meredith, A. (1995). Terry's learning: Some limitations of shulman's pedagogical content knowledge. *Cambridge Journal of Education, 25*(2), 175-187. doi: 10.1080/0305764950250205

Monk, M., & Osborne, J. (1997). Placing the history and philosophy of science on the curriculum: A model for the development of pedagogy. *Science Education, 81*(4), 405-424. doi: 10.1002/(SICI)1098-237X(199707)81:4<405::AID-SCE3>3.0.CO;2-G

Nielsen, W.S., Triggs, V., Clarke, A., & Collins, J. (2010). The teacher education conversation: A network of cooperating teachers. *Canadian Journal of Education, 33*(4), 837-868.

Nilsson, P. (2009). From lesson plan to new comprehension: Exploring student teachers' pedagogical reasoning in learning about teaching. *European Journal of Teacher Education, 32*(3), 239-258. doi: 10.1080/02619760802553048

Nilsson, P., & Loughran, J. (2012). Developing and assessing professional knowledge as a science teacher educator: Learning about teaching from student teachers. In S. M. Bullock & T. Russell (Eds.), *Self-studies of science teacher education practices* (Vol. 12, pp. 121-138): Springer Netherlands.

Peterson, R., & Treagust, D. (1995). Developing preservice teachers' pedagogical reasoning ability. *Research in science education, 25*(3), 291-305.

Ronfeldt, M., & Reininger, M. (2012). More or better student teaching? *Teaching and Teacher Education, 28*(8), 1091-1106. doi: http://dx.doi.org/10.1016/j.tate.2012.06.003

Sánchez, V., & Llinares, S. (2003). Four student teachers' pedagogical reasoning on functions. *Journal of Mathematics Teacher Education, 6*(1), 5-25. doi: 10.1023/A:1022123615355

Shinebourne, P. (2011). The theoretical underpinnings of interpretative phenomenological analysis (ipa). *Existential Analysis, 22*, 16+.

Shulman, L.S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14. doi: 10.3102/0013189x015002004

Shulman, L.S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1-23.

Smith, J.A., & Eatough, V. (2007). 3 interpretative phenomenological analysis. . In E. Lyons & A. Coyle (Eds.), *Analysing qualitative data in psychology.* (pp. 35-51). London: SAGE Publications, Ltd.

Smith, J.A., Flowers, P., & Larkin, M. (2009). *Interpretative phenomenological analysis. Theory, method and research.* (1st ed.). London: SAGE Publications Ltd.

Smith, J.A., & Osborne, M. (2008). Interpretative phenomenological analysis. In J. A. Smith (Ed.), *Qualitative psychology : A practical guide to research methods* (2nd ed., pp. 53-80). London: SAGE Publications Ltd.

Solomon, J., Duveen, J., Scot, L., & McCarthy, S. (1992). Teaching about the nature of science through history: Action research in the classroom. *Journal of Research in Science Teaching, 29*(4), 409-421. doi: 10.1002/tea.3660290408

Starkey, L. (2010). Teachers' pedagogical reasoning and action in the digital age. *Teachers and Teaching, 16*(2), 233-244. doi: 10.1080/13540600903478433

Taber, K.S. (2014). Shifting the culture of science education to teach about the nature of science. *Teacher Development, 18*(1), 124-133. doi: 10.1080/13664530.2013.879004

Teixeira, E., Greca, I., & Freire, O., Jr. (2012). The history and philosophy of science in physics teaching: A research synthesis of didactic interventions. *Science & Education, 21*(6), 771-796. doi: 10.1007/s11191-009-9217-3

Timoštšuk, I., & Ugaste, A. (2010). Student teachers' professional identity. *Teaching and Teacher Education, 26*(8), 1563-1570. doi: http://dx.doi.org/10.1016/j.tate.2010.06.008

Webb, M.E. (2002). Pedagogical reasoning: Issues and solutions for the teaching and learning of ict in secondary schools. *Education and Information Technologies, 7*(3), 237-255. doi: 10.1023/A:1020811614282

Youngs, P., & Bird, T. (2010). Using embedded assessments to promote pedagogical reasoning among secondary teaching candidates. *Teaching and Teacher Education, 26*(2), 185-198. doi: http://dx.doi.org/10.1016/j.tate.2009.03.011

Appendix A

Appendix A Pre Unit Teacher Educator Interview

<u>Pre Unit TE Questionnaire</u>

Planning

What are your main learning intentions for students when teaching this physics unit?

What skills, ideas/ concepts are important for the students to learn and develop in the teaching of physics and this unit?

    Why do you think they are relevant?

Could you explain, briefly, your teaching plan/outline of the content being taught and teaching approaches for teaching that content during the unit?

What are your “pedagogical reasons” for choosing each of these approaches?

    Do they vary for each particular cohort from year to year?

When planning, how do you reflect on what and how you intend to teach?

    Do you do this before, after and/or during your classes?

Teaching

Could you specify what knowledge, skills and methods are important in the teaching of this unit as a teacher-educator?

How do you focus your course to meet your learning intentions/aims during the semester?

Do you encourage your student teachers to challenge traditional practices and take risks within their own teaching?

    If so, what sorts of activities/arguments/thoughts do you use to do that?

    Why do you think those activities/arguments are important and useful and could lead them to improve their own pedagogy?

    How do you assist them to form their own pedagogy of practice as beginning physics teachers?

How do you recognise that your student teachers are learning how to teach physics or are meeting your learning intentions?

Appendix B Weekly Teacher Educator Interview

Weekly short interview

Depending on the particular class taught, ideas delivered, and actions, during each class, the short interview will focus on general or particular situations, idiosyncratic to each class.

General pedagogical reasoning questions about the class

What do you think your students learnt today?

Could you explain your thinking during the class that lead you to teach in the way you did?

How do you know if the lesson was successful?

In what ways was it successful?

Do you think the students learned what you wanted them to learn? How do you know?

Why is this important to you and to your students?

For a particular situation/problem/question/debate within the class

Why did you ask that question? / Why did you choose to create discussion/debate about it?

Why is that so important to you?

What kind of answer did you expect from your students?

Why did you choose to handle the question/debate in that way?

Appendix C

Appendix C   Post Unit Teacher Educator Interview

<u>Post Unit TE Questionnaire</u>

General questions

Were your learning intentions/aims successfully achieved during the unit?

What are indicators of these?

Did the students react/learn the way you intended? How do you know?

Was there anything surprising or interesting in the classes this semester? Why?

During the classes, did you need to change or re-orientate your original teaching plan?

If so, how did you know that you had to change your teaching plan in that way?

During the semester we talked about several interesting moments within the teaching sessions.

(Choose at least two and include here).

To what extent do you think you were successful in helping your students learn in those moments?

Could you explain your thoughts about it and your reasons behind choosing the particular way you actually taught it?

How did you know that this way might be successful?

How do you know that your students learnt in the way that you taught them with that particular pedagogical approach?

To what extent will the student teachers' response change your next year's lesson plan for this unit?

What skills/attributes/knowledge do you now think that your student teachers are equipped with to teach Physics in secondary schools?

Any final comments about your pedagogical reasoning when teaching a Physics discipline unit to student teachers?

Appendix D Student Teacher Interview

<u>Indicative Individual Student Interview Schedule</u>

General questions

What have you learnt about teaching physics during this unit?

Are these important to you? (Please explain yourself)

Did you feel encouraged to learn during the classes? Why did you feel in that way?

During the classes, did the teacher change his approach?

If so, can you explain your own learning experience when that change happened?

Were his teaching strategies appropriate in helping you learn to teach about Physics?

During the semester we lived several interesting moments within the teaching sessions.

(Choose at least two and include here).

To what extent do you think you were able to learn in those moments?

Was it a successful learning experience?

Could you explain your thoughts about why that teacher's reasoning/arguments/leading was successful? Why? / Why not?

What did you learn from that particular pedagogical approach?

What skills/attributes/knowledge do you have now to teach Physics in secondary schools?

Any final comments about your learning experience, as a student teacher, within this unit?

Appendix E

Appendix E Survey

Part A. Demographic information

Gender

Male	
Female	

Your age is:

	Below 25 y.o.
	25 - 30 y.o.
	31 - 35 y.o.
	Above 35 y.o.

Part B. Student views on the Pedagogical reasoning (PR) of the Teacher Educator

For the next 13 items, please read the statement and then choose one of the 5 choices that best reflect your thoughts and experience. Please note that there are no right or wrong answers. The survey ends with 6 open questions in which we would like you to clarify your thoughts.

1. The learning intentions of the unit were clearly stated.

1	2	3	4	5
Almost Never	Not Often	Sometimes	Often	Almost Always

2. It was clear that the lecturer clearly covered all learning intentions during the unit.

1	2	3	4	5
Almost Never	Not Often	Sometimes	Often	Almost Always

3. Now, after the unit, I know that knowledge about how to teach physics is,

1	2	3	4	5
Relatively unimportant	Somewhat unimportant	Neither Important nor Unimportant	Somewhat important	Relatively Essential

4. Now, after the unit, I know what skills are important to teach physics.

1	2	3	4	5
Strongly disagree	Slightly disagree	Neither agree nor disagree	Agree	Strongly agree

Appendix E

5. My approach to teaching physics has had a significant change during the unit because of the lecturer.

1	2	3	4	5
Strongly disagree	Slightly disagree	Neither agree nor disagree	Agree	Strongly agree

6. During the unit I learnt how to teach physics.

1	2	3	4	5
Almost Never	Not Often	Sometimes	Often	Almost Always

7. The lecturer took time to answer questions in class.

1	2	3	4	5
Almost Never	Not Often	Sometimes	Often	Almost Always

8. Sometimes I felt that I did not know where the teaching was going.

1	2	3	4	5
Almost Never	Not Often	Sometimes	Often	Almost Always

9. I felt that the lecturer attempted to explain content/ideas in different ways when he picked up that students did not understand.

1	2	3	4	5
Almost Never	Not Often	Sometimes	Often	Almost Always

10. After most classes I knew that I learnt something new about how to teach physics.

1	2	3	4	5
Strongly disagree	Slightly disagree	Neither agree nor disagree	Agree	Strongly agree

11. At the end of most classes I knew what the lecturer's intentions were.

1	2	3	4	5
Strongly disagree	Slightly disagree	Neither agree nor disagree	Agree	Strongly agree

12. At the end of each class I knew why he taught the way he did.

1	2	3	4	5
Strongly disagree	Slightly disagree	Neither agree nor disagree	Agree	Strongly agree

13. His choice of pedagogy made sense to me.

1	2	3	4	5
Strongly disagree	Slightly disagree	Neither agree nor disagree	Agree	Strongly agree

14. In your opinion, what skills, ideas/concepts, delivered during the unit, were important to you as a physics teacher?

    a. Why are those important to you?
    b. Do you feel that the lecturer and his pedagogical approach helped you to achieve these?
    c. Explain your thoughts about the lecturer´s teaching approaches.

15. Did you feel lost sometimes during a class? If so, please recall one situation and briefly explain it. How could the lecturer have helped?

16. Any other comments you would like to make about the Pedagogical Reasoning of the lecturer in this unit?

Appendix F Human Ethics Certificate of Approval

MONASH University

Monash University Human Research Ethics Committee (MUHREC)
Research Office

Human Ethics Certificate of Approval

Date:	**29 July 2013**	
Project Number:	**CF13/2117 – 2013001102**	
Project Title:	**Exploring the pedagogical reasoning of a Physics teacher educator**	
Chief Investigator:	**Dr Adam Bertram**	
Approved:	**From: 29 July 2013**	**To: 29 July 2018**

Terms of approval

1. The Chief investigator is responsible for ensuring that permission letters are obtained, if relevant, and a copy forwarded to MUHREC before any data collection can occur at the specified organisation. **Failure to provide permission letters to MUHREC before data collection commences is in breach of the National Statement on Ethical Conduct in Human Research and the Australian Code for the Responsible Conduct of Research.**
2. Approval is only valid whilst you hold a position at Monash University.
3. It is the responsibility of the Chief Investigator to ensure that all investigators are aware of the terms of approval and to ensure the project is conducted as approved by MUHREC.
4. You should notify MUHREC immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.
5. The Explanatory Statement must be on Monash University letterhead and the Monash University complaints clause must contain your project number.
6. **Amendments to the approved project (including changes in personnel):** Requires the submission of a Request for Amendment form to MUHREC and must not begin without written approval from MUHREC. Substantial variations may require a new application.
7. **Future correspondence:** Please quote the project number and project title above in any further correspondence.
8. **Annual reports:** Continued approval of this project is dependent on the submission of an Annual Report. This is determined by the date of your letter of approval.
9. **Final report:** A Final Report should be provided at the conclusion of the project. MUHREC should be notified if the project is discontinued before the expected date of completion.
10. **Monitoring:** Projects may be subject to an audit or any other form of monitoring by MUHREC at any time.
11. **Retention and storage of data:** The Chief Investigator is responsible for the storage and retention of original data pertaining to a project for a minimum period of five years.

[redacted]

Professor Nip Thomson
Chair, MUHREC

cc: Assoc Prof Bruce Waldrip, Mr Dario Alberto Maringer

Postal – Monash University, Vic 3800, Australia
Building 3E, Room 111, Clayton Campus, Wellington Road, Clayton
Telephone +61 3 9905 5490 Facsimile +61 3 9905 3831
Email muhrec@monash.edu http://www.monash.edu.au/researchoffice/human/
ABN 12 377 614 012 CRICOS Provider #00008C

Appendix G Teacher Educator's Interview Transcriptions

Sample – Pre Unit Interview

	Timespan	Content
1	0:03,2 - 0:23,0	I: Yeah. So... this is a... consist in two parts, first one is about planning and then coming to teaching. **What are your main learning intentions for students when teaching this physics unit?**
2	0:23,0 - 0:26,0	TE: Do I make some clear, sorry
3	0:26,0 - 0:29,0	I: What are your main learning intentions...?
4	0:29,0 - 1:57,0	TE: Oh, my learning, Ok, well I guess one is to... well, my objective is to trying make it, so they'd have got a clear understanding of what the course requirements will be at the senior into the physics end of teaching secondary school. So years 11 and 12, they´ve got an understanding of what the demands on them as a teacher, would be. But also my intention is, always to focus on looking at ways of improving conceptual understanding. So, rather than teaching tips and tricks about teaching Physics, is a great practical experiment you can do, or is something that you'll, you know, be surprised at... when you look at it, you know, it's can be [Inaudible] people, or something like that, um... It´s a matter of looking at more deeply, I think, in terms of the course. So the students get some understanding of the reason why students might think the way they do. So, it's sort of alternative conceptions that they might have that they came into it. So, the pre-service teachers have got an idea of what's in the kids heads before they even start to begin to try change their opinion, not to think that there all empty, and that it's starting with a clean slide, and the kids known nothing, because often the kids know a great deal, and they just don´t take that on any consideration.
5	1:56,0 - 2:11,0	I: Do you use teach within the class, like today, in this way, like they were students, this is your ...
6	2:11,0 - 3:16,0	TE: I think I'm taking them on two levels. One is the... I´ll trying model somethings, within the class were they would be the role of "the students", yeah… and then there will be other opportunities where I've expecting the sort of play a bit of a role where they´re "the experts", you know, where they draw upon their existing knowledge that they have or experiences that they had throughout the, you know, on the undergraduate or graduate degree, and they share that information with the other students in the class who may not have a tip in that particular field. So, is a matter of... sometimes modelling and they play the role of "the students" so, they can see what's like to be a learner and, you know, in particular in areas where they may not feel very confident or strong. But, in other areas it´s an expectation that they will, actually have a depth or strengths that they're wanted to share with the other students in the class, so they will all became a

	Timespan	Content
		bit richer about that area that they know so much about, and I don´t, cause I don´t know...a lot!
7	3:16,0 - 3:43,0	I: Ha, ha. Yeah, Ok. Um... **What skills, ideas or concepts are important for the students to learn and develop in the teaching of physics and this unit?** Um, I mean ...um, what do you expect that your students learn, as skills as ideas about.
8	3:43,0 - 5:07,0	TE: Skills, Ok. I guess the skills I´m trying to teach is, one of creating problem solving, because they gonna be...they gonna be encountered lots of problems during their teaching careers. And then they [Inaudible] to come up with solutions to each one of those, those problems in order to make the, the life enjoyable and, you know, that they´ve can actually progress forward, I guess professionally, in the classroom as well. Um...So, it's a...yeah, looking at problem solving skills, I think that´s really quite important. I think they need to have some understanding of the sort of research, that´s is actually taken or is gone down with um.... in the area of physics because, certainly, physics education has been one of the more richly investigated areas, when it comes to all of the science education method areas. I think, you know, there is a lot more papers being written on conceptual understanding about physics than there has perhaps on conceptual understanding on biology, and...and I said that, I could be, I´m sure biologists might argue against that, but ... but I still believe that this is actually the case, that they has been far much much more research done on investigating...um...students understanding of physics than, I think, a lot of the other method areas.
9	5:07,0 - 6:33,0	TE: So, they need to be aware, of some of those, particularly if I´m trying to teach this idea of... umm..., you know, the students that they´ll be teaching, have ideas already in their head, that they've already got alternative conceptions. Um... then, it´s important that they have an understanding of that sorts of ideas that are there, not comes true from the research has been done in those areas, mostly, come quite a few years ago, but that´s important. Um...additional skills would be the idea of...um, having some, well, being able to ask good questions about aspects of learning that they´re actually happen in the classroom, um... the idea of involving students in practical work with a purpose, so that it´s actually an authentic task, so they're carrying up in the classroom. Um...and I´m think properly developing skills in... um.... authentic assessment as well, so what is a good assessment task, which actually authentically assesses the learning objectives that you´re actually intending to do. So, I think that need to be able to do that as well. That´s probably the highlight once as standard for me, but I mean this is out those in terms of know good computational skills, and having a depth knowledge in the all range of the study design, and all the usual sort of aspects, aspects that you expect as well.

Appendix G

	Timespan	Content
10	6:33,0 - 6:52,0	I: Yeah, so, when you ask something to the students you...um...you are thinking about...um... showing...the skills that they need to...um.... have or maybe develop in the unit.
11	6:52,0 - 8:09,0	TE: Absolutely, um...well I guess the little section I did on energy today...um...was a good example of me probing...um... their understanding of what that particular concept might be, because, for me I think is an area that is often confuse by kids, and some of that confusion comes from the fact that the teacher who are teaching have a confuse as well. So, in particular....the area that where that happens a lot is, you know, electricity. Understanding electricity is usually really poor, and it is poorly taught as well. But energy, I think, is one which is so topical and, so... um... so much in the public eye, you know, you´re only got on you turn on the television and someone is telling you something about energy and this is happened to students all the time, that they have actually, this very grand notion of what energy is when, in fact, actually doesn't exist. Um... so, you know this is a computational concept...um, yeah, so, I think, to highlight it is like that with I have to, actually begin to question their own knowledge about this, after we gonna be the only trained professional in the classroom... um, you know.
12	8:09,0 - 8:15,0	I: So, sounds to criticise our own knowledge.
13	8:15,0 - 8:45,0	TE: Yes, yeah, absolutely, yeah. Well, at least ...umm...yeah, be critical of what you know; reflect on what you might know and try to identify the areas that, you think, you might need to improve on. Because often, we think we know something, but it is not until there are some difficult questions from students, who ... often, you know, don´t know very much about it, so they ask embarrassingly awkward questions, sometimes, because they don´t know enough to, actually, ask what we think is a sensible question...
14	8:45,0 - 9:21,0	I: Yeah...umm...ok...we...we pass this (Why do you think they are relevant?), and then...the next one. **Could you explain, briefly,...umm... your teaching plan or outline of the content being taught and teaching approaches for teaching that content during the unit?**..Umm...this is kind of...if you can explain...umm...like your...umm...big ideas...and...
15	9:21,0 - 10:43,1	TE: Yeah, ok...umm...yeah, I'll trying take a lap. Umm, I guess, this multiple point that I'll trying address in the design of the curriculum ...umm...one is to concentrate, I guess, on supplying them with a ...or and creating and getting to think about, all that sorts of problems they´re gonna encounter on their practicum, when they go out

Appendix G

	Timespan	Content
		actually, into a classroom. So, is sort of like getting them practicum ready, in a sense. Umm… that they've got an understanding of what the study design is; if they know the major topics, the sorts of assessment tasks, may be their [Inaudible] of the allocated tools there is in the year 12, that sorts of stuff. Umm… some ideas roughly the time that they need to spend on each of the...umm...content areas, within the courses, and also a rough idea of... maybe the sorts of experiments that they likely, to need to be across...umm...the majority of teachers might use within those areas. And that´s pretty much...umm... encapsulated in a document that I hand out, about week 2 of the course where, is quite a breakdown into the sort of timelines, the sequences, the content area, and the likely experiments that they can actually use...umm... to...unpick that...the content within a classroom.
16	10:43,1 - 11:57,4	TE: Umm... I get them to think about the sorts of... like....umm...to come out with some goals, and personal goals that they mean to improve on. Most of them are aware that they are... they are very good communicators or they're poor communicators or... they can see areas in their own professional practice that they need to improve, and so, there is a sort of a goal settings, which is I will be doing next class, before they´ll go on the five weeks prac in again, but...umm...probably, I´m still as important, particularly, because it is the last opportunity, I guess, to get mentors to help them with those areas, so in that sense is...is quite important,... umm... but, I guess, the first semester course, when they go out from the very first time, is the one when they have the most angst...they don´t know what to expect, they got no idea how is gonna play out and, you know, that does result in a certain number of them walking away from the course because, teaching in a classroom it´s just not quite what they expected, so we have, you know, maybe 5 or 6, who actually left the...the course because, it didn't hold ...the expectation that they...that they had ...we can´t meet the expectations that they had.
17	11:57,4 - 13:01,0	TE: Umm...other big ideas such as... There's a whole practicum ready in this, I guess, that I look at. And then the idea that, in fact, teaching physics needs to be done differently to what, I think, happens a lot out there, particularly with an older approach to teaching physics, which tended be focus very much on...umm..., you know, using equations to model and computations, and crunching of numbers...umm, because I think physics needs to move away from that. Physics is [inaudible]is not proving to be highly successful engaging kids with this current model that we have, and allow that model changing and changing significantly; I´m not sure is changing rapidly enough to attract students back, to want into studying physics. So therefore, during this crisis, and a crisis use to be needed to do something differently to what we´ll been doing in the past, because the numbers are just, not there, in terms of students' interesting.

Appendix G

	Timespan	Content
18	13:01,0 - 14:00,3	TE: So, I think we have to look at highly creative and engaging ways of getting kids more interested in [learning] physics, and often all that means is doing things, I think, a bit differently. So we look at something like the... balloon activity this morning which was a very practical focused activity ... And, I know that even though that´s a forty minute exercise, they will be some of the students that will use that, or a variation of that, in some way to develop something that might be a bit more engaging in their classes. So, it's a sort of a great creating wave … doing an activity in some sense. And I guess I'll keep those sorts of things because the feedback that I have from other teachers when I go back out, or students I have like five or six or ten years ago are going "I´m still doing this", you know, … the numbers of that the kids are really interested and excited in doing things like that.
19	14:00,3 - 14:55,0	TE: So, I mean, another one I do is get into build some model rockets and we launch them out here on the...on the oval, and then they look at all of the ways that they can investigate that; by measuring the angle, calculating the high, you know, working out the acceleration of the [inaudible] rocket. All of that sorts of computational stuffs that you can do. Now, you can do that with a textbook and with some [inaudible] rocket as well, but, is far more exciting in authentic do actually, watch something take off and try to collect the data yourself, and I think that´s the way of catching kids' attention as well. So, they have to be feeling comfortable after be able to take on activities like that, which actually push you or, those teachers to do things, which are, more than open up a page 13 or page 14 of the textbook and then turning into the next page, because that´s not gonna cover, I think, in this world now. Kids are not gonna be engage by that.
20	14:55,0 - 15:03,8	I: So, you don´t know where do that kind of experience will ran with the students?
21	15:03,8 - 15:14,8	TE: Don´t know, no. So it´s a way of, I think, giving them the confidence to tackle some creative activities, that be gonna be highly engaging for students.
22	15:14,8 - 15:25,0	I: So, in that way. Did you expect some...some different reaction from the students in the...in today's class? about the balloon thing.
23	15:25,0 - 15:59,0	TE: Umm... There would be some students [who are] confident ... There would be some students they'll all go, "I´m not quite sure, what we would be doing today", you know, "we´ve come in here, and I´ve made a plastic balloon out of, you know, plastic bags"... Forty minutes, is a long time to spend on it, and it is. But, in fact, unless you invest some time in those things, I don´t believe they'd believe it is important. I couldn´t stand up there and say "this is a really important activity, you need to be able to develop these skills", but I'm not even prepared to spend five minutes on it. Ha – ha - ha...
24	15:59,0 - 16:14,0	I:Ha,ha...because I´m thinking about it...that problem....during two

	Timespan	Content
		hours and....after your class, and now I´m thinking, may be you expect something like this, from your students.
25	16:14,0 - 17:44,0	TE: Umm...I expected be some kick back, you know, the...the...some students won´t be satisfied by that, because they want see this being...umm, you know, sort of "academic work", ok. And the work of what physicists should be doing, but...but I think, the work of what they perceive a physicist should be doing, probably tends to be the old model of highly computational work, and dealing theoretically with a...in a formula, putting numbers in crunching and answers...umm. And here is that's part of work physicists do, it´s no doubt about that, and particularly high school physics...um...but these are people who are being trained to...to teach physics not just to senior level, where most of them want actually teach. But, I have to be able to teach physics down to, you know, the lower grades as well. And the lower grades mains, actually, not doing that, what they doing is, the sorts of tasks that we move on today, which are highly engaging for year 8 or year 9 kids. Umm...yeah, we can still unpick some of the physics about why the balloon rises, why the air expands when is heated. Had you make it... a good balloon shape by looking at how you can set up the mess to be able to do that. These are all really good, I think, very strong authentic tasks, that the students [inaudible] find engaging...umm, excuse me [clearing his voice]... and I've seen that they have finding engaging from...umm...from, actually doing that in the classroom myself.
26	17:44,0 - 17:48,0	I: [big pause] So
27	17:48,0 - 17:49,0	[Pause] Now I´m drinking water.
28	17:49,0 - 18:03,0	I: Ha-ha... So, **What are your "pedagogical reasons" for choosing each of these approaches,** that you are talking about?
29	18:03,0 - 18:06,0	TE: Umm...difficult question...
30	18:06,0 - 18:06,3	I: Yeah...is it?
31	18:06,3 - 19:09,0	TE: Ha, ha, ha...umm...ok. I think the ... the pedagogy that I´m trying to model, I guess, in the classroom, is one that providing a range of activities, which are suitable for a highly differentiated class, because, maybe in a physics class is a tendency for the not to be quite as differentiated as there is in, you know, maybe a math class or a geography class or history or something like that, because they tend to be...be self-selecting, particularly when I get two year eleven or year twelve, like the last two years. Students, you know, are drowning into that, either enjoying physics or they not. Umm...so that means they tend to be a bit more functional in terms of there...umm...a similar ability. However, there still...umm...I think if we're try to bring...encourage students to take physics in the higher [inaudible] of

	Timespan	Content
		the school rather than just [inaudible] level or something.
32	19:09,0 - 19:58,0	TE: Then, we have to be mindful of the fact that...that means that we gonna have more differentiated classes than we...than I have had in the past. Particularly if we wanna have more people doing physics, then that means is gonna be a bigger bell shape curve, and it´s gonna be more people spread across that. And therefore, we need to provide tasks which engage all of those students. And so, that will mean some of them more have to be very activity based, and some of them can be really [inaudible], you know, and thought provoking as well. So you have to meet the needs of all of those students, and that means a variety of tasks, which means a variety of pedagogy, ok...So, you have to pick and choose your pedagogy that's gonna enable you to present differentiated activities which target the variety of students you likely to have or, it love to have...ha-ha.
33	19:58,0 - 20:07,3	I: So...big...big...umm...kind of idea of teaching and learning...umm... yeah.
34	20:07,3 - 20:08,0	TE: Yeah, yeah...
35	20:08,0 - 20:10,0	I: yeah...may be this scare about your...
36	20:10,0 - 20:12,0	TE: Ha, ha, ha...
37	20:12,0 - 20:13,0	I: you have to may know....ha, ha...
38	20:13,0 - 20:13,9	TE: Ha, ha, ha...
39	20:13,9 - 20:27,6	I: Ok...umm. **Do they, I mean the pedagogical reasons, vary for each particular cohort from year to year?**
40	20:27,6 - 20:30,6	TE: Ok, ...I miss... I miss main key word there...I wish...umm
41	20:30,6 - 20:39,0	I: The group of students from one year to the next year, did your reasons change?
42	20:39,0 - 20:40,0	TE: I see...
43	20:40,0 - 20:41,7	I: Year after year.
44	20:41,7 - 22:31,0	TE: Do they vary much...um...[pause] I don´t think I varied a great deal. Probably if I look back over a period of three years, I tend to, probably, just make small changes, over that time, rather than come in real something, in dramatically new. Umm... there has been, for reasons of course's structure this year, the need to, probably, create a biggest change, and it´s because it´s now being...umm...taught over two semesters instead of one. For years to this, I...here I had one semester weeks to teach physics method, which really means four classes or five classes by the time, yeah, take five weeks out, seven

Appendix G

	Timespan	Content
		classes, yeah. So, up gone from seven classes to fourteen classes...umm.., which means I have the opportunity to pack a lot more in...umm...and, I guess I'm drowning upon some of the things that I would create few...maybe is more than eight years ago, in a sense, because that´s when the course was a two semester course, as well. So, this year...yeah, it´s...it´s a bit more in the course, which actually gives me a little bit more time to hit some issues, which...umm...just the absolutely three big king issues of getting out... getting on prepare to go out on the practicum...the idea of attacking conceptual understanding and emphasising that. And...umm...I guess, just skimming the map, in general, to ask and response to questions. So...umm...I got a little bit more room to play with, so I can, actually spend some time doing things like the balloon task, which...they may not appreciate, at the moment, but probably a bit further down the track, they'll get "Oh actually that´s what he meant"
45	22:31,0 - 22:33,0	I: "That was a good idea"
46	22:33,0 - 22:44,0	TE: That´s right, yes. So, I think, some of the things...are immediately useful to them, but there're a bit more useful further down the track...umm...unless I look upside. Ha, ha, ha...
47	22:44,0 - 22:56,0	I: Ha-ha-ha....umm...**When...when planning,...umm... how do you reflect on what and how you intend to teach?**
48	22:56,0 - 23:00,0	TE: Umm...
49	23:00,0 - 23:02,0	I: When you are thinking about the...
50	23:02,0 - 24:13,0	TE: Yeah...umm... I guess I'm trying to put myself into their position.... what is it that... I will want to know, if I didn´t know a great deal about going out and teaching physics. So what would be some of the key things.....and I guess...that the course reflects that, I think, the things that I think...umm...would be most helpful...umm...I have a teacher who comes in each year and spends an hour and a half, of nearly two hour session...unpacking all of the things that, you know, he does as a physics teacher, or has done for, I mean he´s taught physics for thirty years or something, in high school physics, and he comes in with a huge amount of resources of, all burned on a CD, and he hands up to them. So, in a sense ... umm...is a great ...he takes a bit of pressure off me, in terms of being out with to provide them with resources, which they expect to be given, you know, they expect that they gonna...somehow pickup all of these wonderful physics resources...umm...
51	24:13,0 - 25:32,8	TE: But the reality is, that the face of teaching is changing so rapidly, that...umm...all of the wonderful simulations in Java, applets and ICT resources, that where around five years ago...umm...aren't really applicable, probably five years from now. There'll be something else

Appendix G

	Timespan	Content
		at this...you know, is evolving all of the time. So, in a sense, I think, he´s able to walk in and provide what is some of the key resources that are really quite current, because he´s a current teacher, you know, teaching those things. In that sense, I'll never have that currency because I'm no longer teaching. I mean, I taught in high school and taught these courses at the same time, for about six years, and I think that was, probably the best of both worlds for the students. Because they got someone who was current in terms of teaching … and can come in and share all the experience I had yesterday, you know, about teaching things. So, I think that´s the best world, unfortunately is not the best world for the person who's doing although, because, huge amount of work...ha-ha-ha...as I discovered to trying do that for six years...and is simple not...well, wasn´t sustainable for me...to continue to do that.
52	25:32,8 - 26:41,0	TE: So, I´ll try to use the other teacher coming in to provide some of that currency, in terms of resources and, you know … the best practice that works … But, there´s no point having a magic bunch of resources and no plan on how to unpack them, or what´s important... what do you emphasise out of those resources... I think that´s where the key underlying objective of teaching physics comes from. You have to develop some sort of plan; you have to have a plan on behalf of how learning occurs, you have to have a plan on behalf about... what´s important, in terms of the big picture, ... because without that all that you got is an internet full of resources and no way of deciding what´s good and what´s bad, because there is a lot of bad stuff out there as well
53	26:41,0 - 27:06,0	I: ....yeah, you know, the...the...problem with the balloons...there is some of kind of explain in the website...it...it just come with the...some idea of a different....different pressure, I mean, but don´t take care about the...the rubber of the balloon...
54	27:06,0 - 27:20,0	TE: That's right...yeah...most of the situations are a...that you find, deal with a...soap bubbles, you know, which behave perfectly, but balloons don´t behave perfectly.
55	27:20,0 - 27:33,2	I: Just one...one...concept...o one...umm...how to say...is like you pick a force, mass and acceleration, and you´re...you´re just looking to the mass.
56	27:33,2 - 27:38,0	TE: One aspect, yeah...absolutely.
57	27:38,0 - 27:38,4	I: Ok...
58	27:38,4 - 28:26,0	TE: I guess, I´ll just continue. It was also quite deliberated attempt in mind, to trying find some other context, where that problem was encountered, which is why I attempt through the, you know, propeller on a boat or something, to talk about that. But, because I think that, I´m trying to model air to them...this idea, of that you take something

Appendix G

	Timespan	Content
		and yes, you examine it over a very limited experience or range of experiences but, what you got be able to do as a teacher is then take that and look at another context, where the science things are actually at work. And so that´s my, I mean, it was a delivered attempt to try on pick something which is completely out of left field, you know, they go "What?" ha-ha-ha, you know, "I don´t know now what he is talking about?"
59	28:26,0 - 28:27,0	I: Where is the connection?
60	28:27,0 - 28:50,7	TE: There, where is this going to. And then they´ll go "Oh, wow", you know, that´s...is so. This idea of linking things that look like they´re totally unrelated. But, actually, they´re not unrelated, they´re all the same thing, is just that is a context that they haven´t even thought about...umm...and they need to be able to do that with their students as well. Because then, all world become interesting...ha-ha-ha...if you can see all of these links with the things that people are talking about.
61	28:50,7 - 29:06,0	I: Ok...umm [big pause]...So...umm, you answered this question (Do you do this before, after and/or during your classes?)...Ha, ha, ha...Ok.
62	29:06,0 - 29:12,0	TE: I´ll happy if I tackle another one, am I doing [inaudible], so if the answer is consistent I'll be happy.
63	29:12,0 - 29:29,4	I: Yeah...we now...we're looking about the teaching. Umm...**Could you specify what knowledge, skills and methods are important in the teaching of this unit as a teacher-educator?**
64	29:30,0 - 29:31,4	TE: What´s word was the last word, sorry?
65	29:31,4 - 29:44,8	I: Yeah...um...um...skills and methods...methods those are important in the teaching of this unit as a teacher-educator?
66	29:44,8 - 29:49,6	TE: Oo...as a teacher-educator, so the skills, the knowledge...
67	29:49,6 - 29:51,4	I: And methods
68	29:51,4 - 29:53,0	TE: That are important in teaching this course?
69	29:53,0 - 29:54,0	I: Yeah...
70	29:54,0 - 30:50,8	TE: Umm...well. I think...ok...in terms of knowledge, I think it´s important as a teacher educator to have some knowledge of the resources that have within the area, ok...umm...so that can be share with the students, and those insights, in terms of important...umm...important key ideas that come up in the research, that they´re aware of that... and I guess, in a sense I'll trying to do that with even last years, the last week´s class, when we looking at this...umm...you know, what´s quite a significant push in the US at the

	Timespan	Content
		moment on this idea of modelling, you know, physics modelling, and their idea of a step by step learning cycle would might ... might be happy. So they need to be aware, I think, of the...that sorts of model exists...umm...and...They can choose from them. Ha, ha, ha...
71	30:50,8 - 31:56,8	TE: No...what...what model aligns with their thinking and their objectives and their school or where they be gonna be teaching. They might...they know there´s some choices that can make about the sorts of learning [inaudible] that they might wanna use. Umm...and may not leaving something they wanna do, that´s fine, but at least they got an idea, that these...these are some of key ideas that they're actually up there within the method area and itself. So, I think having knowledge about those sorts of thinks is important...umm ...I don´t see that knowledge of content is that important, and probably, I mean...you know, I´m argue this with other physics educators, some of them plays [inaudible] a significant importance on...umm...looking to unpack knowledge about specific content that they likely do encounter, so this week we should be looking at momentum, and next week we should be looking at photonics, and the week after we should be looking at synchrotrons and how they work, because these are all part of the course.
72	31:56,8 - 32:21,8	TE: But, I think, my time, seven weeks, is so limited. There in fact to trying spend the time … unpack the course when the students are going to do that, anyway, they’re going to have to teach it, they’re going to have to open their textbooks, they’re going to have to become familiar with the content. Umm...and, you know, sink or swim, that would be their task but I think that´s their task, it´s not my task.
73	32:21,8 - 33:30,0	TE: My task is to give them some ideas about the ideas that are already in kids' heads about the content ... to give them some teaching strategies, and ideas about how to unpack the content .... I don’t spend time focusing on the content, because, it will be, I think, a complete waste of my time and, actually, waste of their time too. Because they're going to unpack the content anyway ... They’re going to have to do it, the night before, you know, it's usually where that happens. “You´re going to look at it the night before you have to teach it”, and so, all of them come back, I think, they´re a bit devastated when I said that, initially they all go “but I thought you’re going to spend time looking at how, you know, to teach momentum or motion or something like that". And, although we might spend some time looking at some pracs, or some of those discussions problems might focus on these things ... they come back from the teaching round, though, appreciating that, in fact, actually..."I can do that", "I can spend my time on the content", "Content is not such a big issue that I thought it was going to be", "Now, tell me why I need to teach it, and how I can teach it, not what I have to teach"”, you know.
74	33:30,0 - 33:37,0	TE: I think, I only answered one part though, which is knowledge, so

	Timespan	Content
		we go still on skills? Is it the other one?
75	33:37,0 - 33:44,7	I: Yeah...umm... because....you, as a teacher educator, you´re, I think, maybe thought about the...
76	33:44,7 - 33:45,2	TE: the skills?
77	33:45,2 - 33:48,0	I: Yeah, what skills do you need... for doing that?
78	33:48,0 - 34:45,8	TE: Umm...well, ok I talked knowledge, I´ll talk skills [inaudible]...umm, I think the skills I need to be...is to be...pretty competent, being able to use ICT...Information, Communication stuffs...So, the idea that...umm, and is...is a lot of physics resources they´re out there, so I spend a fair bit of time...umm, I guess, [inaudible] them to investigate where those resources are, or having to investigate, in order to do assignment tasks. One of the tasks, in the first semester course, is that they need to prepare a multimedia type item...umm...which they did in present back to the class. So one on gives them skills in presenting, two on gives them skills in being able to...umm...sift and filter, through all of the crap that´s out there, to find something that it´s actually useful,...umm...and then the third thing is presenting that back to the students, in a way that´s, you know, powerful...umm.
79	34:45,8 - 35:46,8	So, they get, I think, to develop skills in all three of those sorts of areas. One in being able to select an item, one being able to identify how they could use it to unpack the content, and the other one is, actually, presenting it in a classroom, as well. So, I think, that particular task, really helps to build a lot of the skills in the ICT. But, critical...that...the...across those sorts of skills, now I think, and also skills in assessment, knowledge in assessment, reasons for formerly assessment, ...summative assessment...and the importance of being able to have activities, which provide the teacher with continuous assessment happening, with they can get feedback about. Where the students are...where there are that particular point in time, so they can make, I think...umm, you know, competence assessment of were the classes knowledge lost at that particular point in time. Do they move on, do they back and re...look at it again, have to make those decisions all the time? Ok?
80	35:46,8 - 35:59,0	I: **How do you focus your course to meet your learn...learning intentions/aims during the semester?**
81	35:59,0 - 36:07,0	TE: How do I focus the course?...Umm...yeah pretty broad question there.

Appendix G

	Timespan	Content
82	36:07,0 - 36:08,0	I: Yes.
83	36:08,0 - 36:36,5	TE: Struggling don't know how that might be different to some of the other ones. Let me have a crack out that....umm....The focus probably shifts as the course unpacks, from one preparing them for the teaching rounds, to the second one preparing them to be able to skilfully find resources. So, that would be a shift...that would occur...umm...yeah, I think that´s probably yet.
84	36:36,5 - 36:39,0	I: Yeah, umm...
85	36:38,0 - 36:45,0	TE: So, that´s answer or not? If you wanna interpret that some another way I´m happy that...ha-ha-ha.
86	36:45,0 - 37:20,0	I: Yeah...is some, some....like ... umm...is in some way...umm...the things are [inaudible]...are running in a different way...that you...that you plan before?...umm....How can you keep your focus, because you...we talked about your...your ideas...maybe.
87	37:20,0 - 38:14,0	TE: Ok. Within the structure of the course. So I have... sort of plan, there is a session, which is the second last...sorry the third last session, so we come back, we have one session...there is another three sessions after that, right? So there´s four sessions after they come back from teaching. The first one I got stuff just plan for that. The last one I have stuff plan for that, because that´s is when the guess presenter comes in. I think the second last when I´ve got stuff plan, which is just sort of tiding at everything. But the second one, that they do, when they come back, I haven´t got anything in there at all, and basically that all be a response to when they come back from the teaching round and they go "Oh God, we did this all of stuff [inaudible] and nothing about this", you know, "can you tell us something about this". So, it´ll be something that I...it will be different [inaudible] that I´ll have to sit down and workout to try what best addresses their needs.
88	38:14,0 - 38:48,0	TE: So in that sense, I think helps to keep the course...umm...current, because it´s responsive to what their needs are...umm, but the really is only one lesson, where I think I can do that...umm...because it´s a luxury, because it´s so little contact. Anyway, so I'll trying hit all of the other key big idea things that I have, and in trying on one class, freeware I would respond to, what I think might be the best thing they'd needed that time. And then will change from year to year.
89	38:48,0 - 38:54,0	I: Well...this, kind of, when something happen...umm...from the students. But, Ok.
90	38:54,0 - 39:31,0	TE: Umm...ok...well, you know, let me think about that, for a sec.

Appendix G

	Timespan	Content
		Umm...well...ok...well...today one´s response we´re always was trying to unpack the idea of the rotational tork. It was responding to last week, where some of them didn´t go so well, you know, I´m mean and all still quite confuse, I think, no doubt about that. So, responding with...with that information, I think, most of them worked out there today filling much more...happy with...with how I tackled that now, to whether were before.
91	39:31,0 - 40:35,3	TE: We had another situation in the first semester … which was two weights, which I put down on a desk, you know. So one like that [a glass of water]… you know, and a pencil. And we went through the whole formal textbook sort of approach, drawing diagrams of weight force down, and reaction force of the table up and all of that, and they´re all feeling very bored, and ... "yeah of course, I know about this, you know, I set that a million of times … these sorts of diagrams". And then I hit them with the question "though, this is fantastic, but the table is very smart, because the table knows, how hard to push". The pen knows how... hard to push up, you know, the reaction force, you know, a certain amount. But for the really large weight, it knows to push really hard, because, it has to still over there. So my question to them was, you know, "How is it that the table knows how hard to push?".... None of them could answer that question at all.
92	40:35,3 - 41:08,6	TE: And...and they´re feeling completely uncomfortable, by the effect of such a basic question, that any year eight student might ask them, or less grade, "how is the table knows, how hard to push"...umm...none of them have got [inaudible] any answer on that at all. So, we spent a great amount of that time talking about that particular problem...umm...and then, looking at ways, that being able to see how the table actually deforms, and the deforming of the table, you know, monitors how hard the reaction force is back up. And then they're all feeling much happy with that.
93	41:08,6 - 41:57,0	TE: But...I let them go over two periods, like over two classes, so they´re feeling very uncomfortable ... for some period of time, because, I think it is important to feel uncomfortable ... it really motivates people … So rather than give them the answer straight away, I´ll say "I´ll discuss this over next week, but you will have to think about it" and there wasn´t one person in the room who didn't have to think about it, or had to go away to start Googling things to try to work out what was going on, because, they didn't have an answer ... Well, one of those skills is looking for ... cognitive dissonance ... where two things , just don't seem to match what you think. And you can create that, I think, really...is a strong motivator.
94	41:57,0 - 42:11,4	I: Yeah, ok...um. **Do you encourage your student teachers to challenge traditional practices and take risks within their own**

Appendix G

	Timespan	Content
		teaching?...their own teaching?
95	42:11,4 - 43:05,0	TE: Well...umm, well yeah. Certainly with encourage them, and I talk a lot about, you know, risk taking ...umm...and how important that is, that actually takes risks. I see that it's being critical to professional growth. Teachers aren´t gonna grow professionally, unless they´re prepared to take risks, to trial things that might be new and, some of them work, and some of them won´t. But then they reflect on them, and they work out ways to being able to modify, change them, so they´re in fact that become better. And some of them might be just rubbish, and them decide that throw [inaudible] all together and, and, it was a silly idea. Umm...and I guess that, in a sense, a model that ...with the modelling thing, that I did last week, were I never done that before because some of the resources that I need just became available at 2013 [inaudible] it´s happening out in Utah.
96	43:05,0 - 43:39,5	TE: And... um...so, being able to collect all of those resources and then have a crack and being able to model that again, as an approach...umm...I think, provides them with examples of risk taking. Sometimes it works, sometimes it doesn´t. I let them know today that I notify that, in certain ways...given a bit more information. They seem to be happy about that, "yeah, if I was gonna do what I do differently too". So they thinking about how they can take something like that...that model, and then work out to maybe...work...adapted to whatever situation is.
97	43:39,5 - 44:04,0	TE: I guess I strongly believe that there is no one solution, that you can roll out across the all bunch of classrooms ...umm...you really have to look at your students, you have to know your students well, and if you know that, then you´ll make much better informed decisions about what things are gonna work in that classroom and, because things often have to be modify, done differently from one class to another.
98	44:04,0 - 44:43,0	I: Yeah...so...umm...what...**what sorts of activities or arguments or thoughts do you use to...to do that?** You...you say something about...um...the...the experience with the balloon, the experience with the ...umm...balance...do you have another kind of activities or ideas that...
99	44:43,0 - 44:58,0	TE: Umm...I guess the assessment task, which is the discussion problems, might be something that does that? …Umm... Is that right? Is that what you mean?... May you just read the first part of the question, you know, and I'll see if...
100	44:58,0 - 45:11,0	I: mmm...Ok, yeah...this is about the...**if you encourage student teachers to challenge the traditional practices and, if so, what activities or arguments or thoughts do you use to do that?**... You

	Timespan	Content
		are....
101	45:11,0 - 46:10,3	TE: Yeah, well, I think, yeah, my answer there will be the use of those discussion problems. Because, what they often do is, challenge the students... they think they know things, and then they... when they actually look at the problem discovered that they don´t...umm, and so, they going go away and then ... latter research it. But, the critical thing is, how do you unpack that...that, that knowledge...to an audience that doesn´t know the things that they actually know. So they have to thought of....the problems challenge them to work on two levels. The first level is, how do arrive to the solution...to the problem that seems reasonable, even is not the correct solution, how do you arrive at any solution to the problem. And the other one is, then, how do you convey...what´s the best way to being able to convey an insight, of the conceptual understanding of the problem to the audience that you´re trying address, whatever the age or levels of the kids.
102	46:10,3 - 47:06,0	Because a solution that you might came up with, you know, in a year nine class won´t be the same solution that you´ll use in a year eleven class. Umm...I think to deal with what might be still the same problem, because you might be looking at a totally different way of...of...umm...analysing the situation, using tools that year nine students don´t know about, so, you can´t use it. So, you have to look at the way that´s appropriate to the conceptual understanding of the kid that you´re actually, dealing with. Umm...so, those problems, I think, challenge them as, you know, they beginning to be quite happy to take those risks and talk about the fact "I didn´t know the answers of that", "I didn´t have a clue", "what is going on here?", and you read some of, those discussions, solutions, and, you know, they begin to feel as they´re, actually, they´re not the experts again; they´re learning all the time.
103	47:06,0 - 47:14,0	I: Yeah...at...at… at the end of the process, you can think about this "you know", something in that.
104	47:14,0 - 47:14,5	TE: That´s right.
105	47:14,5 - 47:34,2	I: Yeah...umm...**why do you think those activities or arguments are important and useful and could lead them to improve their own pedagogy?**...umm
106	47:34,2 - 47:38,0	TE: Ok, yeah, is it all? Is it?
107	47:38,0 - 47:39,0	I: Yeah.
108	47:39,0 - 48:54,0	TE: I think it forces into reflect on...how...umm...how helpful the solution is, that they came up with. They reflect on ...how reasonable it might be to present an argument, and maybe how difficult it is, to

	Timespan	Content
		present an argument to, actually, came up with to the particular solution. So...umm...what am I thinking on the...it´s...it´s one problem which is a rotating wheel, at some point on it, and, you know, every year is always a really strong argument, that in fact, this rotation, you know, that they...The question is: the different points on the wheel relative to the ground, how are they moving...and everyone just goes on the travelling of the speed that the axe is going, the answer, if the wheel is moving along the velocity "v", and every point on the wheel is "v", well, that´s true if...if you don´t have it moving along...moving along, it is just rotating on the spot. Then there's a whole bunch of students are go "Oh, in the top one is "2v", and the bottom one is cero", which is nice, but in the two side ones they just said is "v" and "v". No, actually no, is not, because one side is going up and one is going down, at the same time, as is rotating around. So they begin to unpick it, at all variety of different levels.
109	48:54,0 - 50:24,6	...Umm...another one would be...umm... classic pendulum, which is...like a whole sphere full of water ... and the water is dripping out, and the pendulum is going backwards and forwards as the water drains out of the sphere from the bottom …I'll quickly draw it up so you've got an idea, because it's actually a nice problem… Ok, so this thing is swinging backwards and forwards, full of water, and there are little drips coming out of the bottom from the hole in the bottom, ok? And, the question is, what happens to the ... pendulum. Does the period [time taken for one whole swing from one side to the other] change as it swings backwards and forwards? Well, most students initially look at the problem go "well, you know, "T" squared two "pi" on "l", "g" or something", has no mass in there [i.e. there is no mass in the equation used for determining a pendulum's period], pendulum don´t depend on mass, so therefore "no, they´ll be no change in the period of the pendulum swinging backwards and forwards". They usually look at it a little bit more deeply and realise that in fact the centre of mass is actually dropping [lowering], so therefore, the effective length of the pendulum is getting longer… "Oh, so if the effective length is longer, the period will get longer as well", so they go "Oh, the solution is the period will get longer" … ha-ha. Because it's gets longer for a little bit, but then, as the water drains away, the centre of mass goes back to the original point, as when it was full of water, and so it´s goes back to the same point again
110	50:24,6 - 51:13,4	So, they... Everyone always gets this wrong because, maybe a third of the class says "no change at all", because it is not depending on mass. Two thirds say that it is important because the effective length has something to do with it, and so they're very excited about the fact that it gets longer. And then it´s one third that go "Oh yeah, but then it gets shorter again back to its original amount. So it gets longer, but then it comes back to the same". So it´s usually about thirty percent of the class that will come up with the correct solution but what's nice is

	Timespan	Content
		that they all get the opportunity to see how each other´s thinking is and unpick what it looks like, you know “it´s no mass, therefore…”
111	51:13,4 - 51:18,2	I: So, in that way ...umm...growing in the...they're own pedagogy.
112	51:18,2 - 51:19,0	TE: I think so.
113	51:19,0 - 51:19,3	I: Ok
114	51:19,3 - 51:36,8	TE: That´s the reason I keep those problems in there because, there´re examples of the very thinking process, as that the students. They gonna have to encouraging their students. And it´s not just about the answer that's important here, you know, getting the answer right. I don´t care what the answer is! What I´m interested in is...
115	51:36,8 - 51:43,0	I: There will be always people with some...some...some problems with the...no answer or with...
116	51:43,0 - 52:17,8	TE: Yeah, so the first couple of these problems, they're very tentative about it, because they see that they have to get them right. You know, "I'm a physics graduate, I should know this stuff, this is a test on my ability", and so many of them would run away and googling the answer and come back with a beautifully worked answer, and then I go "well, that´s fantastic", but, you know, that really wasn´t your first thought, was it?. They go "Oh, not really, when I thought, you know, when I thought about it, I thought was really, don´t gonna change". In I go "Well that´s the answer I want you to write down. I don't want you to write down what the...the ultimate answer is", "Oh...ok".
117	52:17,8 - 52:47,0	TE: So, by the time I´ll get to the fourth problem or something they´re quite happy to jump in there...have a...go and unpacking their thinking, just as ST1 did today, when ST1 was saying, you know, "the answer is, but actually got it wrong" ha, ha, ha...And so, I mean I think that´s a huge step forward because, you know, no one care that you got it wrong. There we got ST2 wrong as well, but doesn´t matter, you know, what´s important is that, actually, the thinking behind them, and being able unpack that thinking, I think.
118	52:47,0 - 52:49,0	I: Put their brains over there.
119	52:49,0 - 52:50,0	TE: Yeah.
120	52:50,0 - 53:08,0	I: Umm...maybe this one, you already answered, but, umm...**How do you assist them to form their own pedagogy of practice as beginning physics teachers?**
121	53:08,0 - 54:04,4	TE: Umm...I guess, I'm a bit tentative about that. I don´t...I don´t

	Timespan	Content
		believe there is...there is one way doing things...and my way is not the right way, for everybody. It´s may way. Ha-ha-ha. So I think they...umm...my approach will be do encourage them find their way of doing that, because they gonna do things differently themselves. Some of them will be highly focused on, you know, the...umm...computational side of physics because that´s where the joy last for them. And if that´s where the enjoy is, then they hopefully can convey some of that joy to their students...umm...but, it won´t be for every student...the...that´s where the joy [inaudible], it might be the practical side of, actually doing activities, and experiments, and investigations, as that what really got them interested in, and that´s where the joy will be, and that´s, hopefully, where them joy is that they´ll convey to their students.
122	54:04,4 - 54:38,0	So, I don´t think is one way doing this...it´s...there´s lots of different, and they have to work out, that in fact it´s no one way of teaching two different classes in one school. Because they´re different classes, you know, they´ll have different kids in there and...they might vary enormously from across a school, but it certainly varies enormously across schools, and they have to be conscious of that. So, I guess, trying to show them a variety of ways of doing things, so they can pick the sorts of once...the...somehow resonate with them...yeah.
123	54:38,0 - 54:53,6	I: The last one. **How do you recognise that your student teachers are learning how to teach physics or are meeting your learning intentions?**
124	54:53,6 - 55:33,5	TE: Yeah...I guess, that will come through with both, the sort of ...umm...immediate feedback that I'll get within classes, so, the types of discussions that I´ll have like the...we talked today, where they are quite happy to contribute ideas back. Sometimes is awkward silences, but I don´t care...ha, ha, ha...I´ll just let them be awkward until someone speaks, and usually...someone does, as they did it again today, you know, I just point out that ... It´s important sometimes to have...that silence, you know, in classrooms...
125	55:33,5 - 55:34,6	I: Yeah, they are thinking...
126	55:34,6 - 56:21,5	TE: Yeah. And if they can see that...to have what a piece to being in awkward silence, in... in that room. Yet it still... [Inaudible]...initiating some thought, we work through it, and therefore that don´t becomes as awkward. Then I think that´s a really valuable step from to take into their classrooms as well. Ask the difficult questions, let people think about it and sometime to think, and then respond...umm...we don´t all have an answer for everything in...in 0.3 of a second...the average response time in a classroom is 0.6 of a second, between the teacher asking something and answering...umm...that´s just that right,

	Timespan	Content
		"they´re should be just be 0.6 of a second"...no thinking time at all.
127	56:21,5 - 57:30,0	TE: So, I guess feedback from students in the class, and of course the reading assessment tasks, as well. So, they'll do the assignments, which unpick their thinking...um, There are students who are no longer in this semester because, their thinking was erratic, unclear and not very professional, and so they've failed those assessment tasks, and they haven´t been able to go on to complete the course. So, and there is a number of them who ... do not meet the criteria, I guess. But that´s, you know, as in terms of all assessment fairly objective, ok. There are still rubrics up there that can assess the work, but it still comes down to, I guess, a bit of a good feeling about, whether or not, someone's actually meetings the rubric or not … Is this person someone I could recommend as a physics teacher?... The answer is no, then I'll look at ways of....not...not doing that.

Appendix H Student Teachers' Interview Transcriptions

Sample. ST 4. Part 1.

	Timespan	Content
1	0:08,0 - 0:14,0	I: **What have you learnt about teaching physics during this unit?**
2	0:14,0 - 0:19,3	ST: I think um...
3	0:17,0 - 0:19,0	I: You can think first, and then...
4	0:19,3 - 1:17,5	ST: Yeah, I'll go to a little bit of think [pause] I think using...um, using [TE name] as a model, I think it´s really great to see [TE name] up there, at all-time skills actually modelling, a lot of the concepts. For instance, the thing that always sticks in my mind and I wrote this in the reflection as well, was ... When he demonstrated... the curvature of the table [when we explored the reaction force] by standing on it, and … the reflected laser point actually moves down a little on the wall … That one sticks in my mind and I think that captures... so many aspects of teaching. I think it captures the modelling prac, you know, the prac is actually modelling the thing, but it also captures his commitment, because he´s committed to the thing, he´s standing on the table, you know, to show us this... his whole body, it all brings commitment to the teaching.
5	1:17,5 - 1:54,0	ST: Um....also, you know, just the...the little such a physical demonstration of the theoretical concept. You know, 'cause he start of with the question, he start by saying, you know, um...you know we all know about Newton´s third law every force has an opposite reaction bla, bla, bla....every action has an opposite reaction and the....he would saying, when you place something in the table, the table automatically knows push back at the same...with the same force, I mean, someone would say is a pretty smart table, right, and he was...he was basically...um.... demonstrating or ... I wanna, don´t say modelling again, but he was...he was...
6	1:54,0 - 1:55,1	I: he was open
7	1:55,0 - 1:56,0	ST: sorry
8	1:55,0 - 1:57,0	I: open
9	1:57,0 - 3:01,0	ST: Yeah, yeah, he was open to it, and he was doing a mock question that is what actually occurs in a class, you know, someone could ask the question of that, right. What if someone asks the question? … So, I think it´s about ... you know, asking the right questions, I think, even as a teacher. So, you´re thinking about the question that the students would ask in … [about] any concept, anything that you want to teach. What are the questions that you come up? Um...and then think about a way to engage them, think of a way to put yourself all heartedly into the teaching, 'cause endears the teach into the students, you know, they ...they feel that connection with the teacher, they see that the teacher tries very hard. And then it's fun, it's using equipment in a variety of

Appendix H

	Timespan	Content
		ways, in different and innovating ways....um. And then the assignment, and many things too. That was kind of the main things that always come to my mind, first when about [TE name]'s Physics class.
10	3:01,0 - 3:42,0	ST: But in all the assessments writes. So, you know, doing alternative conceptions was so very interesting ´cause it gets...gets me to think about concepts from the students' point of view, put these assignments all the same sort of questions, what are the questions that students could have? Um...so, what other perspective are students could have? Um...some of the other perspectives we have...um. I mean the interview was good, getting us to interviews in a physics class, and earing about students conceptions. I learnt a lot about how...yeah, students actually could think about. Um...but I might come back that if it's more that comes to my mind. That´s probably main things that come through...that comes first, yeah.
11	3:42,0 - 3:52,0	I: There are important to you...there are important to you, I mean, there is something that you feel like you learn something, some really good stuff for your teaching.
12	3:52,0 - 4:32,4	ST: Absolutely absolutely, yeap.
13	3:56,0 - 4:03,0	I: You feel that there are important. Why do you feel there are important?
14	4:03,0 - 5:34,0	ST: Why do I feel there are important? Um...well, I feel that there are important because when I was in class, I was engaged. So I think that...I think those points were important because those things engage me when I was a student. So, just reflecting on what I found, you know, connected with me, you know, I...when... I did, you know, ..[Inaudible], I did my degree, my undergraduate studies in other area, and the teachers...they were very very... they won´t very good... they were very unengaged, they won´t very exciting. It wasn´t a good experience. Um, but coming into...into this course, where you...we had formal teachers, actually teaching you how to teach. It was a totally different experience. I feel that I was engaged. So yeah, that´s why. I think it´s important because...um, me being a student in that class, work for me, that´s why would be important and would work for the students as well. Um...but if you wanna go into the details, that ok [Inaudible], I come back asking questions, why asking questions is important. Um... Well, I think asking questions is important because ... it´s an active part of learning, right? If you're just sitting there …you're not extending your "so what", by asking follow-up questions. You´re not actively learning; someone is trying to pour water into your head, and ... and it just flows away, right? So I think asking questions is one sign of active learning, so I think that´s why.
15	5:34,0 - 6:48,8	ST: Um...so I think modelling, I think modelling is important because, um...it´s a way that engages the other senses as well, rather than just a theoretical...just a theory, a formula. Yeah, actually rely back to real

	Timespan	Content
		world, and that´s how we experience science anyway, right, as a key, that´s how we enjoy something, through...through interaction with the real world. Um... I feel sometimes special when I get to a high school a high level high schools will lose that, because it´s more about the theory, the formulas, and getting them the right marks, and exams, and you lose the thing that makes you connect the science to start with. Um...and I think the other reason why I...the teacher being committed is important, it´s...well I think it builds a connection, because if you see that the teacher's actions, that they worked so passionately enough to organise, to organise from the start, to stand on the desk, to be committed, you know, to put on the show. You know, it means a really passional work it needs [Inaudible]. Yeah, that´s I can answer the question.
16	6:48,8 - 6:48,9	I: Yeah, perfectly. Maybe we can do part two outside
17	6:48,9 - 6:54,0	ST: ´cause it´s won´t be loud, yeah, sure, sure

Appendix I

Appendix I Class' Transcriptions

Sample – Week 2 Class

	Timespan	Content
1	0:00,0 - 0:07,5	TE: Ok, [inaudible] maybe, have a look at this [inaudible]
2	0:07,0 - 2:52,0	Question Task: Which contains the greatest amount of energy? A document with the question and a drawing with six objects. [ST Talking indistinguishably]
3	2:52,0 - 2:55,0	TE: Ok. Anyone have any fairly strong [inaudible]
4	2:55,0 - 3:07,0	[TE and STs talking indistinguishably] TE: You think is all the same?
5	3:07,0 - 3:13,9	TE: Depends of what type of energy you´re talking about? Use an example which comes with different types of energy.
6	3:13,9 - 3:21,0	ST1: Well...well you thought the chemical energy in the dynamite and the battery it´s...um...potential energy...um...
7	3:21,0 - 3:23,0	TE: well, and the rabbit may have some [inaudible]
8	3:23,0 - 3:23,8	ST1: yeah, absolutely
9	3:23,8 - 3:25,0	STs: Ha-ha-ha
10	3:25,0 - 3:28,0	STs: [talking indistinguishably]
11	3:28,0 - 3:33,0	ST2: Yes, and it is kinetic energy in the rabbit...as well
12	3:33,0 - 3:34,0	TE: To what extent it still [Inaudible]
13	3:34,0 - 3:35,0	ST2: Mmm...
14	3:35,0 - 3:35,8	STs: [talking indistinguishably]
15	3:35,8 - 3:37,4	ST3: But It´s potential energy
16	3:37,4 - 3:38,0	ST1: Why it is potentially energy?
17	3:38,0 - 3:41,5	STs: [Talking indistinguishably]
18	3:41,5 - 3:43,7	ST3: It´s a lot of jumps, and sprints...
19	3:43,7 - 3:47,5	STs: [Talking indistinguishably]
20	3:47,5 - 3:49,0	TE: Is anyone trying to catch up rabbit, did you?
21	3:49,0 - 3:56,0	STs: [Talking indistinguishably]

Appendix I

	Timespan	Content
22	3:56,0 - 3:58,0	ST3: Chickens are harder
23	3:58,0 - 4:13,0	TE: Ok, so, two solutions so far. One is the...they're all weight a kilogram, therefore it´s exactly the same. And the next solution is... It depends of what sort of energy we´re talking about, yeah? ok? Anything, anyone else got another… take one, like the dynamite, or something.
24	4:13,0 - 4:16,0	[silence]
25	4:16,0 - 4:17,0	ST 3: Huge amount.
26	4:17,0 - 4:19,2	TE: Yes a kilogram of dynamite it's a lot of dynamite
27	4:19,2 - 4:20,0	ST 3: A lot...
28	4:20,0 - 4:22,0	TE: That´s a big bang
29	4:22,0 - 4:42,0	ST4: So I think about energy as...um...what the ability to work. And work is [inaudible] force and [inaudible] distance. Thought that the dynamite might be able to produce...if you light it up....um...
30	4:42,0 - 4:43,7	STs: Ha-ha-ha
31	4:43,7 - 4:48,8	TE: So, sitting here at the moment it´s not reaching its potential.
32	4:48,8 - 4:49,6	ST4: No, it´s not.
33	4:49,6 - 4:51,0	TE: Is that right? Yeap.
34	4:51,0 - 4:56,0	ST5: I was thinking about Einstein and his em ce squared [E=mc2] formula, but that´s modelling [inaudible].
35	4:56,0 - 5:00,7	[STs Talking indistinguishably]
36	5:00,7 - 5:05,7	ST5: Battery have chemical energy, and magnet magnetic fields, so probably [inaudible]
37	5:05,7 - 5:22,7	TE: Lot of energy in magnetic fields. It´s a generator electric fields that you need. Huge amount of energy, and actually [inaudible] got energy [inaudible] ...um, but, you know [inaudible] probably [inaudible], isn´t it. Ok, so...unpack that [inaudible] a bit for us.
38	5:22,7 - 5:44,7	ST5: Um...well, you could think on the em-ce-squared pattern just due to the mass of the molecules [inaudible] in that...um...and then, in addition to that [inaudible], add... other energies, I guess, and magnetism in magnetic field from each sort of portion of mass, start with [inaudible]; energy purely by the mass itself.

Appendix I

	Timespan	Content
39	5:44,7 - 6:01,7	TE: Ok, So, this...the...this [inaudible] sort of like components on energy. One is like the mass equals em-ce-squared, then there is an additional energy that might be there because it's in another form, which is what we [inaudible], you know, ok...anything else? Any other thoughts?
40	6:01,7 - 6:23,0	ST4: Yeah, actually to build not use...the sense it contains is the [Inaudible] on energy. The magnet...the magnet might not contain, what the magnet have is the energy as sort of property of its mass...equals em-ce-squared. But it might be able to. [Inaudible] Although the energy is powered the magnet, but produces a magnetic field that could produce...
41	6:23,0 - 6:23,6	TE: ... a field there...
42	6:23,6 - 6:24,2	ST4: Yeah, so it´s...
43	6:24,3 - 6:28,2	TE: And fields generally need a [Inaudible] of energy to generate a field.
44	6:28,2 - 6:32,6	ST4: Yeah. Probably you said that...it´s a property of the magnet, or....I don´t know.
45	6:32,6 - 6:37,0	ST6: Was energy that made that the field stop [Inaudible] the magnets...
46	6:37,0 - 6:50,0	ST4: Yeah, it´s sort that you say that...the energy, but yet to [Inaudible] struggle a magnet [Inaudible] into the same mass. Which, do you say that would this one contain more energy? Than the other? [Inaudible] well...yeah.
47	6:50,0 - 7:44,0	TE: [Inaudible]...very powerful...Um, you can see this is, actually, a bit of dilemma, really? Ok. And it´s a dilemma that you come across when you'll be teaching your classes. Um...because kids have concepts of energy which tend to think about it... it´s sense of a fluid or some sort of [Inaudible], you know, when you got words like "which contains", ok, it´s supposed this whole... notion that in fact energy is somehow pull into objects, and that contains energy it´s actually [Inaudible]. And then...then is really in there and is waste to being able to extracted, that´s important to sort of what we're unpick in here. Um...yes we can talk about the...the "E equals em-ce-squared" [Inaudible] this, but actually, is no way that we can gave this [Inaudible] batteries to, you know, under go with nuclear fusion or something.
48	7:44,0 - 7:46,0	STs: Ha-ha-ha

Appendix I

	Timespan	Content
49	7:46,0 - 8:05,0	TE: So, you´ll never really gonna be able to recover the energy it be em-ce-squared, from a six volt battery, [Inaudible] by picking the....the atoms apart, and that sorts of nuclear forces, that are actually [Inaudible] all together. And likewise with the other things, you know, there is no nuclear rabbit...that...that you pull the tail off and it explodes.
50	8:05,0 - 8:07,0	STs: Ha-ha-ha
51	8:07,0 - 8:58,0	TE: Ok...um...so, the e-equals-em-ce-squared, it´s actually...a bit of a non-sense idea, in terms of being able to, you know, work out how do you gonna get the energy out of these things, ok, or...or the potential energy that they have to do things. Um, yeah the rabbit can run, and the magnetic fields are very strong, and dynamite hardly explodes if [Inaudible] chemical energy. So, this create the dilemma...in students by ...think and they conceive that´s [Inaudible] instinct are incredible powerful, you know. So therefore we should be able to...somehow make some... you know, equate this things with each other, which of course, reaction up there, "you can´t do it", this is a non-sense question to try and say which one of these things contains more energy. And the strength in your teaching comes from the fact that...in recognising; this is a non-sense question, ok?
52	8:58,0 - 9:56,0	TE: And you gonna be encounter lots and lots of non-sense questions, that kids will gonna throw at you. And at some stage you have to trying capture there, chase and go: "actually; Is this a sensible question for which there is an answer? Or is this just a non-sense question?" ok. So, if you face with something like this, the answer is...it´s non sense, ok. But then, non-sense because why? How do we know that something like this is non-sense? What do you know about energy? Can anyone tell me a little bit about energy? Don´t start do unpick it with the idea of force-times-distance or something, that in work.... work and energy and equivalence on, you know, we can measure energy in joules, in kilojoules, in calories, and all these sorts of... things in terms of [Inaudible] them. But actually, what is energy? If I ask that question; what is it?...Read books about it?...a thousand million problems?...working out the energy of things?...but the question actually is...what is energy? It's a little bit tricky.
53	9:56,0 - 9:58,0	ST5: This is really hard to define.
54	9:58,0 - 10:01,0	[After 3 seconds] TE: Apparently?
55	10:01,0 - 10:03,0	STs: Ha-ha-ha.
56	10:03,0 - 10:04,6	TE: [Inaudible] in this room...

Appendix I

	Timespan	Content
57	10:04,6 - 10:06,5	ST1: Aren´t we physicists?
58	10:06,5 - 10:25,0	TE: physicists?...I...I argue that is, actually is not that hard to define but...So let´s have a prac here. What is energy?...And it´s...don´t fell you got encounter the right answer right now...[inaudible]
59	10:25,0 - 10:27,0	ST2: Something that can make changes?
60	10:27,0 - 10:40,0	TE: Something that can make a change? Ok. So the changes of stage, [inaudible] someone... um...but then...so you got a compress spring and it has the ability to... change.
61	10:40,0 - 10:41,0	ST2: By expanding.
62	10:41,0 - 10:42,6	TE: By expanding...ok.
63	10:42,6 - 10:44,2	ST4: [inaudible] motion...inducing motion
64	10:44,1 - 10:46,0	TE: Something to do an inducing motion?
65	10:46,0 - 10:46,4	ST4: Yeah
66	10:46,4 - 10:47,4	TE: Um...so...
67	10:47,4 - 10:52,0	ST4: So, change is being able on change, and the possibility of change the motion of something else.
68	10:52,0 - 10:57,4	TE: Ok, so you light up the dynamite, and lots of [inaudible] and gases and stuff, go everywhere...
69	10:57,4 - 10:58,2	ST4: Yeah
70	10:58,2 - 11:11,0	TE: Yeah? so, certainly creates a large amount of change, you know, it´s suppose....any other ideas about...energy?.... Doesn´t exist or is it like a substance, or something?
71	11:11,0 - 11:14,2	ST3: [inaudible]
72	11:14,2 - 11:48,0	TE: Work out to release the energy? Yeah. So you have to look at ways to being able to [inaudible] energy or somehow extracted off, whatever it is, but is it physically in the object? 'cause that´s what I´m getting now. Is this something like...um...you know, they're all concept of heat, when people thought the heat was something to do with...like a fluid that flows in and out of objects. We have energy flowing in an animal. So, what´s going in an inanimate object? What´s actually happening in something called [inaudible], when it hasn´t got much energy?.

Appendix I

	Timespan	Content
73	11:48,0 - 11:50,0	ST1: A reaction.
74	11:50,0 - 11:57,0	TE: A reaction? Yeah, ok, any other ideas
75	11:57,0 - 12:03,0	[6 seconds waiting time]
76	12:03,0 - 12:10,0	TE: Doesn´t like to the wait time, always....very awkward, but sometimes is very good.
77	12:10,0 - 12:28,4	ST7: I u...I used to do another way, movement, the more I´m think about...some here is got more energy is like [inaudible] vibrating more or something like that. [Inaudible] you know, a battery is chemical energy [inaudible] whenever that comes moving around.
78	12:28,4 - 13:15,0	TE: Ok. So, it´s probably closely tied with something to do with movement, or being able to create or affect movement in some way. The electric fields might be generated a...can create something like a charge that move...that are forced on a [inaudible] within, within a field, as well, ok. Am...it´s true that most of the students you´ll be teaching will be thinking of energy as something that is bound in and out of an object, ok, so when they calculating the energy, it´s some sort of physical attribute that the object has...and then you convey like...by using whatever formula what you wanna, ok? e-equals-em-ce-squared or force-times-distance, or something like that [inaudible] all sorts of stuff in terms of working out...you know teaching [inaudible].
79	13:15,0 - 13:58,9	TE: Um...but, I think the most powerful way of think in energy is, it´s actually just an accountancy system, ok? It´s a method of accountancy where...see like momentum, for example, we do a calculation by multiply two physical quantities together, and it generate, you know, some sort of derived number, ok, which is a measure of something, but is nothing that actually physically exists; it´s merely a calculation. And energy is the same sort of thing. It´s merely an accountancy system, for keep you tracks [inaudible]. So, and now hand out what would be some very, very clever thinks, ideas, about what energy is, ok? So...
80	13:58,9 - 14:47,8	[TE distributing a document about what energy is]
81	14:47,8 - 15:10,0	TE: Inside first page. Couple of quotes...three, four people [inaudible], ok. [inaudible]
82	15:10,0 - 15:16,0	[STs Talking indistinguishably]
83	15:16,0 - 15:54,7	TE: ...And the other one there...um, it´s a [inaudible] has been used by universities [inaudible] for quite a number of years, with a bit of the definition about... um... the... the energy, as well. Um...which does

	Timespan	Content
		highlight the idea that energy does not exist [inaudible] it´s nothing. It is the way to look at something happening, ok. So, that sort of... quote... quite nice. And...although is these that energy is an imaginary abstract concept, ok? So, when kids come up on stuffs, begin to find that the energy exists...and then...they spend half of their life calculating energy; is, actually, is nothing, ok? It´s merely an accountancy practice, ok?
84	15:54,7 - 17:10,0	TE: Which, reach of the fun and goes on to elaborating as so much to much detail, about a...[inaudible] but...a...he, at this particular amazing course that he ran...um...[inaudible] in the late sixties, were excited to rewrite the entire first year graduate course in physics. And, doing that, he generate a number of...three books, which he called the "red books"...um...[inaudible]...but, he re-write the course in such a way, that um...his approach on measuring things and doing things in enormous sort of way of the...[inaudible] them physics in a physics course...was completely tend of this here upside down. And so, he ended up but, in fact, the people who ended up doing the course at the end will not [inaudible], in fact there is only...very small number of them... undergraduates still a little of math...um. But mostly clear...that´s all of the master students and [inaudible] all of the rest of the universities will come there and listen to the undergraduate course...um...because [inaudible] such of intrigue [inaudible] looking at the world.
85	17:10,0 - 17:36,0	TE: So... um...it´s a fascinating...um...book...also [inaudible] see this course that it use to actually, unpack that. There’s a lot of observations there with this idea of being and [inaudible], and practice... [Inaudible] looking for...um...bricks in a room that they lost [inaudible]... So, and then this is a little bit idea on the page here on energy...as a... [Inaudible] the actual concept...um. It was...
86	17:36,0 - 18:42,0	TE: Is something with “*vis viva*” ... Picking around I thought that content books [inaudible] may room which fairly in about 1905 or 1910, these whole chapters on "vis viva", this idea of a, you know, that was kinetic energy...um, but you know it´s about ...it´s...it was written just as a...like a combination of the number that you´ll calculating between momentum and energy [inaudible] it´s that all into dimensional analysis of these things in those days, but...um, sometimes, we will give you insights as to walk and going on in experiment if you could actually [inaudible] these numbers or "vis viva", or something calculating...Um, so, we refine out, the understanding, whatever it is [inaudible] using this sorts of concepts, but I encourage you to have a read [inaudible] because it might challenge some of the obvious, about what you think, energy was, and

	Timespan	Content
		maybe you have...or you got, a better explanation that you put on the spot, when kids asking what the [inaudible] ok [inaudible] "this is a non-sense question. This is a question you should be asking". [inaudible]
87	18:42,0 - 18:56,0	TE: So, have a read to that...um, it´s, you know, really just meant as a...as a way of stimulating, and I´ll guess, think a little bit about, what that the...what that actually is. Ok, any other questions about that. Yeah.
88	18:56,0 - 18:59,4	ST4: So, what should be the right question to ask it? This is a non-sense question.
89	18:59,4 - 19:00,0	TE: Yes
90	19:00,0 - 19:04,6	ST4: What...what be a....question...question...the way of question that.
91	19:04,6 - 20:05,8	TE: Ok. Useful question would be... looking at similar forms of energy that objects, sort... might contain, and being able to make a calculation between them, so, could be that, if you looking at ...um...three different sticks of dynamite...um...then keep them make some comparison between the...amount of chemical energy that they contain...then you´ll could do a calculation, that enable you to work out the potential work that the explosion could do in terms of its...its ignition, ok. But, what you can´t do it´s calculate the "E equal em ce squared", and try...and they´ve equate that to chemical energy or something. Or a magnetic field or something else. Ok? I mean you...you can make some comparisons between energy across its distance, ok. So, you can...so...these is part energy...[inaudible] potential energy to rise it up here and have got so much chemical energy here in a battery, that it might be able to do that...to rise the object to certain way, work out to ways its [inaudible]...light the object, all that sorts of stuff.
92	20:05,8 - 21:16,8	TE: So, you can cross systems, ok, that´s fine. But to trying...ask one simple question about all of those things, doesn´t make any sense at all. 'Cause we´ve got no way of...of unpacking the energy of the hot water tank an comparing with how much energy there is in a rabbit, you know, it´s the rabbit breathing, I don´t know...breathing, running...um...you know, is it moving, is it sitting there...I don´t know. So, you can´t equate these things, because they're....they're not even...um...comparable. Is that help? Any other question? I...I don´t guess had all the answers to undeceived that? Ok? But… I mean, my job is not giving the answers... it´s just...hope you...you go investigate the answers, ok? That´s what I think my job is. So consider yourselves [inaudible] ok?...in this particular question, about energy...um...maybe you go, and have...more to think about, the fact that....many [inaudible] people, don´t see it has, you know, something

	Timespan	Content
		that exist at all, ok. Which may have be helpful for your students at the year 9, when they´ll coming and go "[inaudible] about energy doesn´t exists"
93	21:16,8 - 21:17,8	STs: Ha-ha-ha
94	21:17,8 - 21:26,0	TE: Probably not the way is that, ok? Because they gonna be...be in highly confuse, "we spend a whole lesson learning how to calculate this thing, and then you tell us that it doesn´t exist", "what are we doing?"
95	21:26,0 - 21:29,0	ST 11: They´ll think [inaudible] why I´ll have ever...calculated.
96	21:29,0 - 21:42,0	TE: That´s right, Why I´ll have ever had to calculate it? Well, you calculate it because it´s helpful, ok? [inaudible] Ok...um, and you moves on...

Appendix J Survey Report

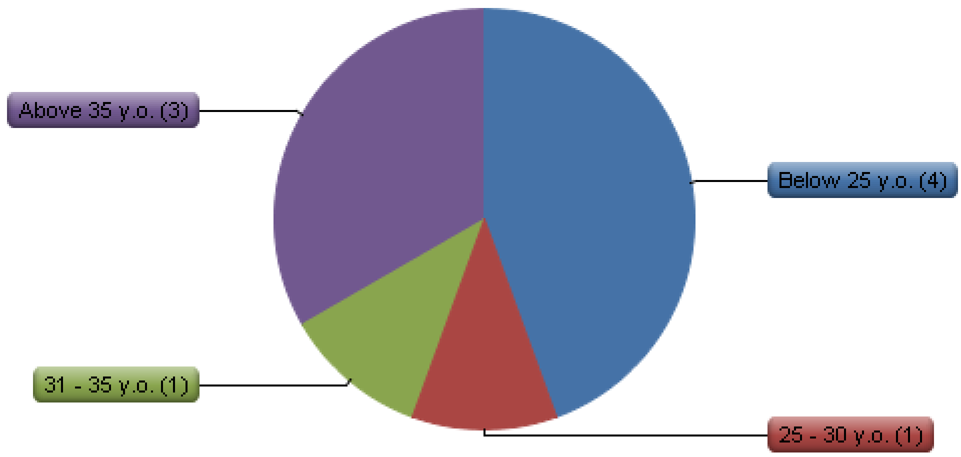
Initial Report

Last Modified: 12/29/2013

1. Gender

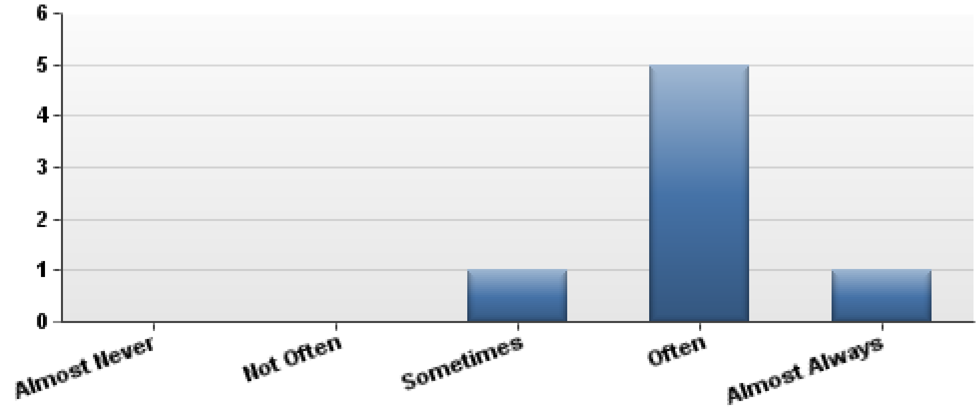
#	Answer		Response	%
1	Male		3	33%
2	Female		6	67%
	Total		9	100%

2. Your age is



#	Answer		Response	%
1	Below 25 y.o.		4	44%
2	25 - 30 y.o.		1	11%
3	31 - 35 y.o.		1	11%
4	Above 35 y.o.		3	33%
	Total		9	100%

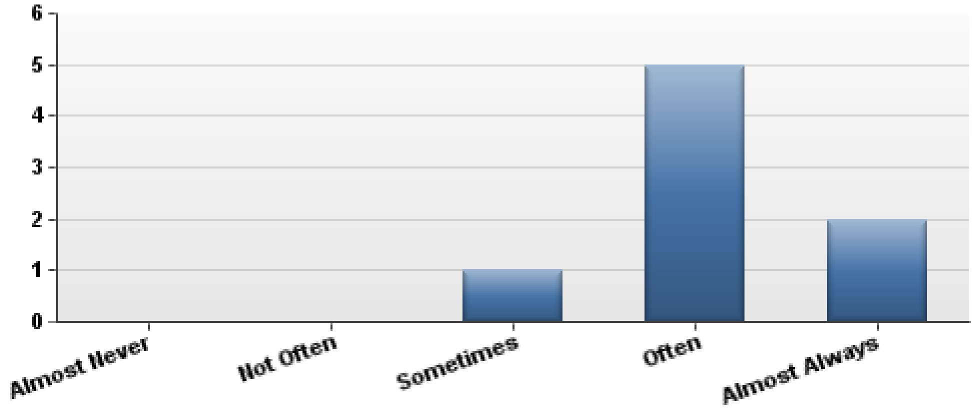
3. The learning intentions of the unit were clearly stated.



#	Answer		Response	%
1	Almost Never		0	0%
2	Not Often		0	0%
3	Sometimes		1	14%
4	Often		5	71%
5	Almost Always		1	14%
	Total		7	100%

Statistic	Value
Min Value	3
Max Value	5
Mean	4.0
Variance	0.3
Standard Deviation	0.6
Total Responses	7

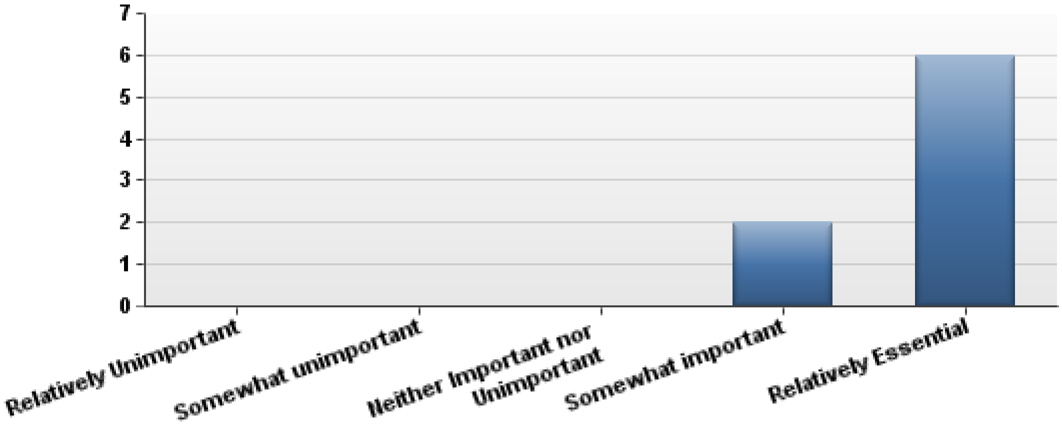
4. It was clear that the lecturer clearly covered all learning intentions during the unit.



#	Answer		Response	%
1	Almost Never		0	0%
2	Not Often		0	0%
3	Sometimes		1	13%
4	Often		5	63%
5	Almost Always		2	25%
	Total		8	100%

Statistic	Value
Min Value	3
Max Value	5
Mean	4.1
Variance	0.4
Standard Deviation	0.6
Total Responses	8

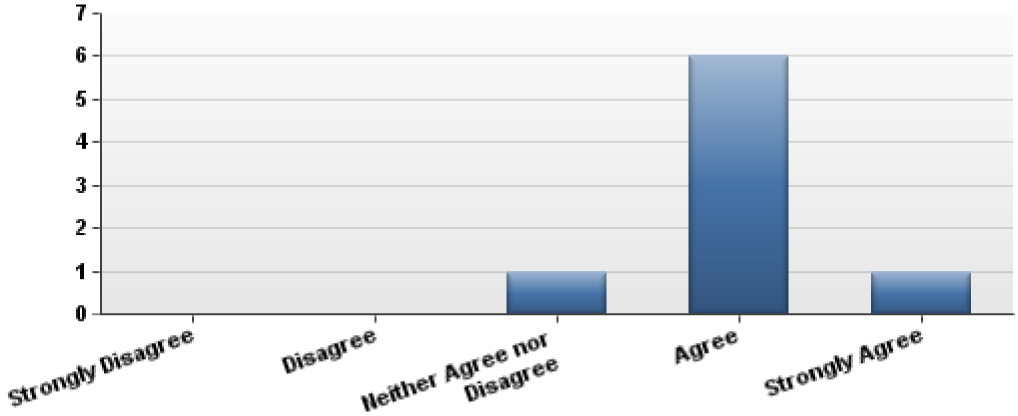
5. Now, after the unit, I know that knowledge about how to teach physics is,



#	Answer		Response	%
1	Relatively Unimportant		0	0%
2	Somewhat unimportant		0	0%
3	Neither Important nor Unimportant		0	0%
4	Somewhat important		2	25%
5	Relatively Essential		6	75%
	Total		8	100%

Statistic	Value
Min Value	4
Max Value	5
Mean	4.8
Variance	0.2
Standard Deviation	0.5
Total Responses	8

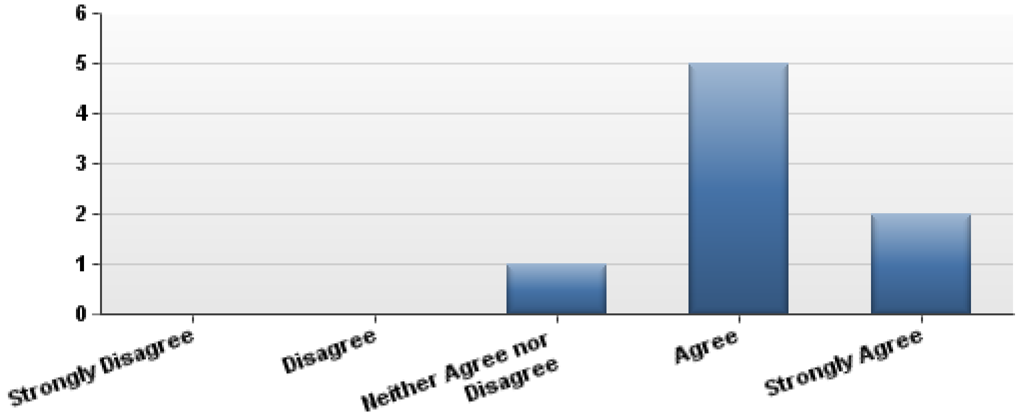
6. Now, after the unit, I know what skills are important to teach physics.



#	Answer		Response	%
1	Strongly Disagree		0	0%
2	Disagree		0	0%
3	Neither Agree nor Disagree		1	13%
4	Agree		6	75%
5	Strongly Agree		1	13%
	Total		8	100%

Statistic	Value
Min Value	3
Max Value	5
Mean	4.0
Variance	0.3
Standard Deviation	0.5
Total Responses	8

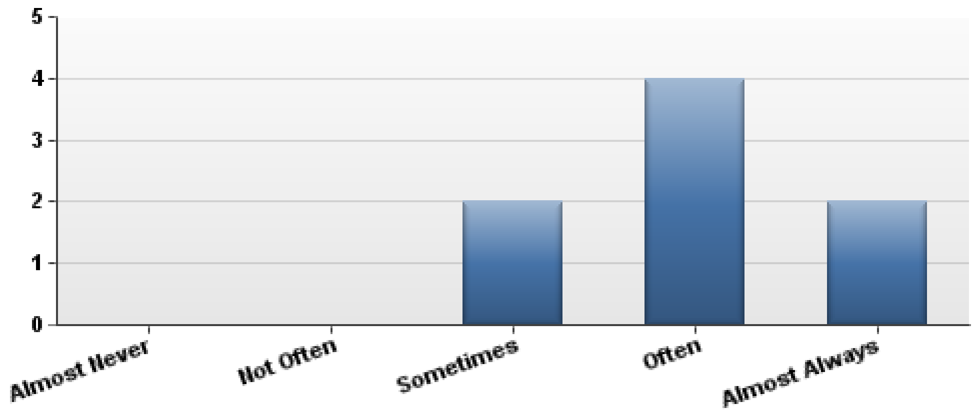
7. My approach to teaching physics has had a significant change during the unit because of the lecturer.



#	Answer		Response	%
1	Strongly Disagree		0	0%
2	Disagree		0	0%
3	Neither Agree nor Disagree		1	13%
4	Agree		5	63%
5	Strongly Agree		2	25%
	Total		8	100%

Statistic	Value
Min Value	3
Max Value	5
Mean	4.1
Variance	0.4
Standard Deviation	0.6
Total Responses	8

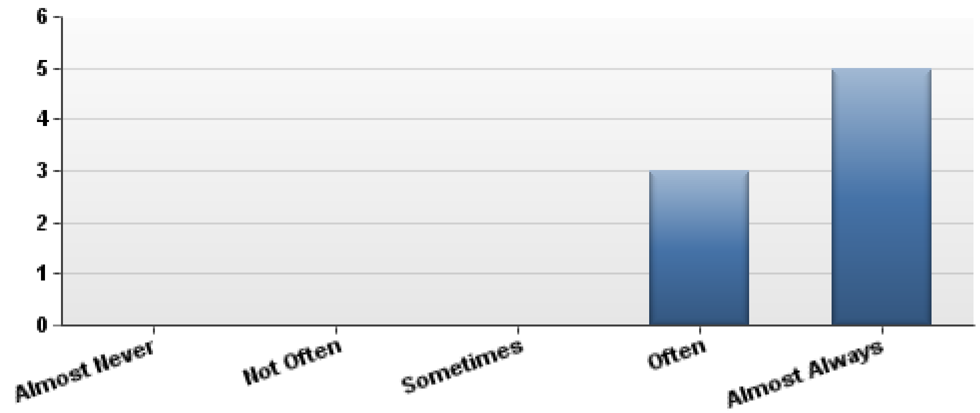
8. During the unit I learnt how to teach physics.



#	Answer		Response	%
1	Almost Never		0	0%
2	Not Often		0	0%
3	Sometimes		2	25%
4	Often		4	50%
5	Almost Always		2	25%
	Total		8	100%

Statistic	Value
Min Value	3
Max Value	5
Mean	4.0
Variance	0.6
Standard Deviation	0.8
Total Responses	8

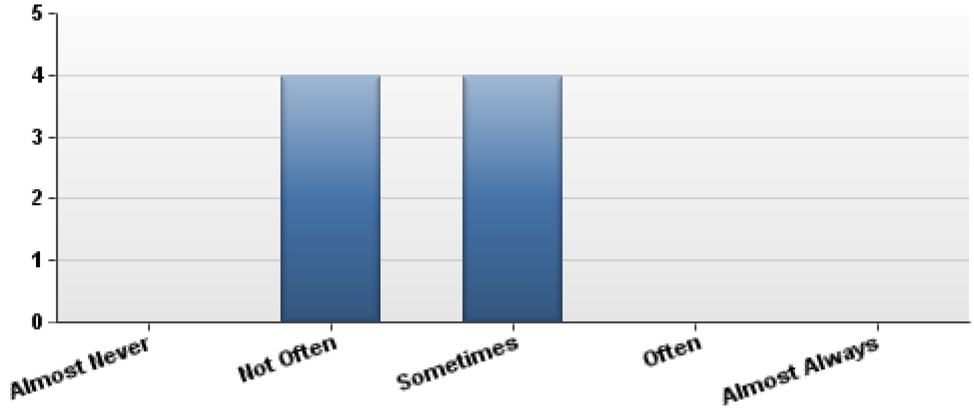
9. The lecturer took time to answer questions in class.



#	Answer		Response	%
1	Almost Never		0	0%
2	Not Often		0	0%
3	Sometimes		0	0%
4	Often		3	38%
5	Almost Always		5	63%
	Total		8	100%

Statistic	Value
Min Value	4
Max Value	5
Mean	4.6
Variance	0.3
Standard Deviation	0.5
Total Responses	8

10. Sometimes I felt that I did not know where the teaching was going.

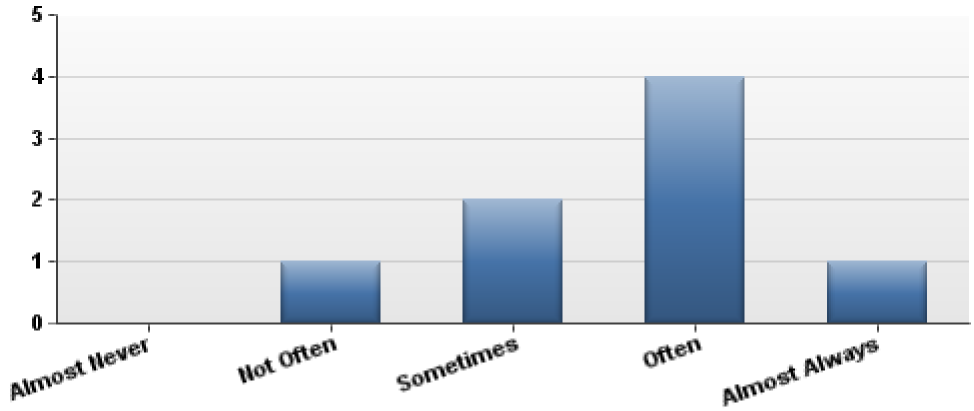


#	Answer		Response	%
1	Almost Never		0	0%
2	Not Often		4	50%
3	Sometimes		4	50%
4	Often		0	0%
5	Almost Always		0	0%
	Total		8	100%

Statistic	Value
Min Value	2
Max Value	3
Mean	2.5
Variance	0.3
Standard Deviation	0.5
Total Responses	8

Appendix J

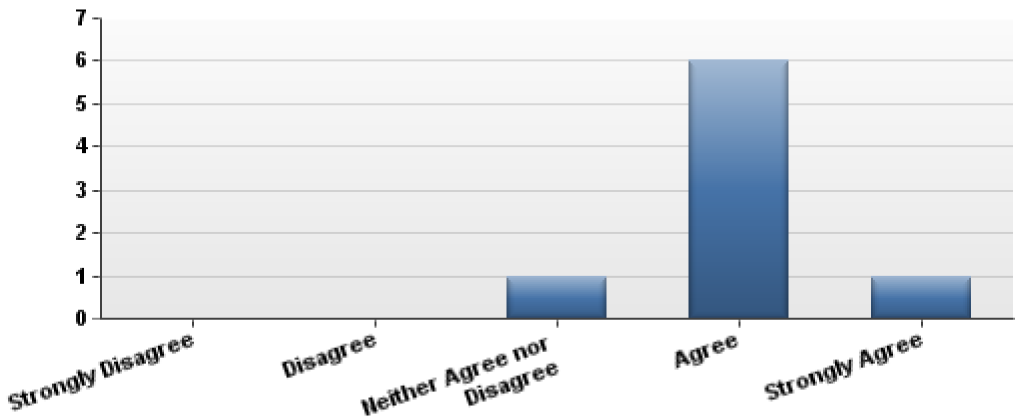
11. I felt that the lecturer attempted to explain content/ideas in different ways when he picked up that students did not understand.



#	Answer		Response	%
1	Almost Never		0	0%
2	Not Often		1	13%
3	Sometimes		2	25%
4	Often		4	50%
5	Almost Always		1	13%
	Total		8	100%

Statistic	Value
Min Value	2
Max Value	5
Mean	3.6
Variance	0.8
Standard Deviation	0.9
Total Responses	8

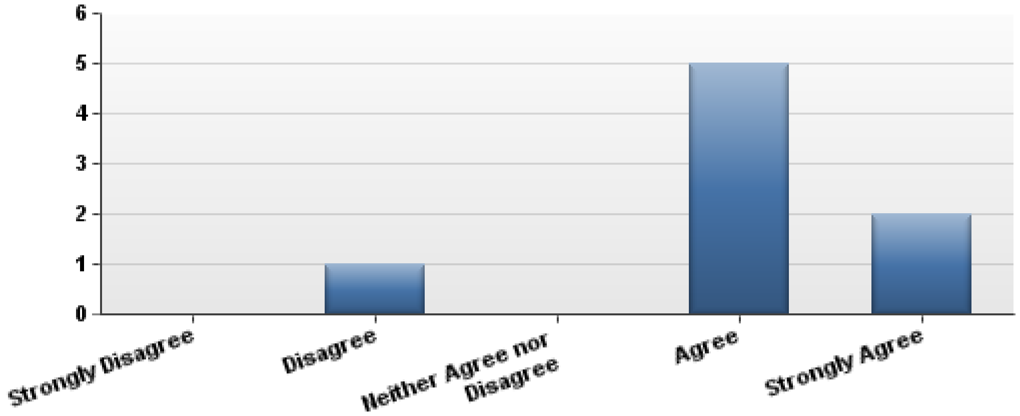
12. After most classes I knew that I learnt something new about how to teach physics.



#	Answer		Response	%
1	Strongly Disagree		0	0%
2	Disagree		0	0%
3	Neither Agree nor Disagree		1	13%
4	Agree		6	75%
5	Strongly Agree		1	13%
	Total		8	100%

Statistic	Value
Min Value	3
Max Value	5
Mean	4.0
Variance	0.3
Standard Deviation	0.5
Total Responses	8

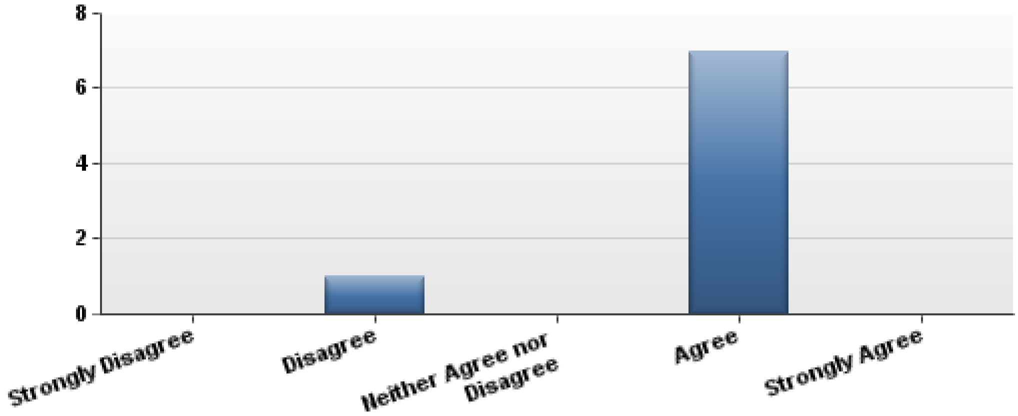
13. At the end of most classes I knew what the lecturer's intentions were.



#	Answer		Response	%
1	Strongly Disagree		0	0%
2	Disagree		1	13%
3	Neither Agree nor Disagree		0	0%
4	Agree		5	63%
5	Strongly Agree		2	25%
	Total		8	100%

Statistic	Value
Min Value	2
Max Value	5
Mean	4.0
Variance	0.9
Standard Deviation	0.9
Total Responses	8

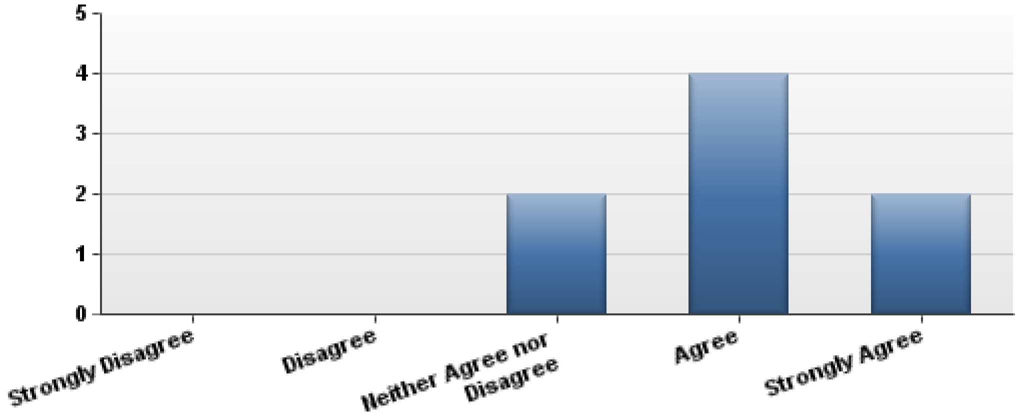
14. At the end of each class I knew why he taught the way he did.



#	Answer		Response	%
1	Strongly Disagree		0	0%
2	Disagree		1	13%
3	Neither Agree nor Disagree		0	0%
4	Agree		7	88%
5	Strongly Agree		0	0%
	Total		8	100%

Statistic	Value
Min Value	2
Max Value	4
Mean	3.8
Variance	0.5
Standard Deviation	0.7
Total Responses	8

15. His choice of pedagogy made sense to me.



#	Answer		Response	%
1	Strongly Disagree		0	0%
2	Disagree		0	0%
3	Neither Agree nor Disagree		2	25%
4	Agree		4	50%
5	Strongly Agree		2	25%
	Total		8	100%

Statistic	Value
Min Value	3
Max Value	5
Mean	4.0
Variance	0.6
Standard Deviation	0.8
Total Responses	8

16. In your opinion, what skills, ideas/concepts, delivered during the unit, were important to you as a physics teacher?

Text Response
Using a Predict, observe, explain approach to activities, awareness of alternate conceptions that students may have.
Activities and strategies that can be implemented in a physics classroom to engage students.
Different ways to teach and promote understanding that I had not been exposed to in my previous schooling, such as CUPs, limited instruction.
I believe it is essential to address student's interest and plan the teaching accordingly.
The idea of 'alternative conceptions' was important to me as a physics teacher. I think the various practical activities run throughout the unit were also important to me.

Statistic	Value
Total Responses	5

17. Why are those skills, ideas/concepts so important to you?

Text Response
The POE style I believe offers a solid framework that engages students in the learning and allows them to challenge their own ideas. Understanding why students have specific alternate conceptions allows better preparation in deciding what to teach and how to teach it.
Physics is not as attractive as a science compared to other sciences like chemistry and biology, so it's important to know ways to attract and engage students in the subject.
They gave me a new way of delivering content and cementing concepts
Student come with various misconceptions. If the learning can be Connected in a way that addressses these misconceptions and takes Care of student's interest as well, then the successful learning happens.
During the teaching of physics, it is important to be aware of student alternative conceptions in order to teach effectively. All students see the world differently, so it is important to take this account in my teaching. This also highlights the importance of checking student understanding throughout the teaching and learning process. Practical activities are a great way of engaging students, fostering curiosity and developing conceptual understanding. The use of practicals in the physics unit allowed me to see pracs from both a teacher and student perspective. As a student in the class I was more engaged in these hands on prac tasks. As a pre-service teacher, I saw the learning potential of these activities and learnt how these activities can be integrated into the physics classroom.

Statistic	Value
Total Responses	5

18. Do you feel that the lecturer and his pedagogical approach helped you to achieve these skills, ideas/concepts?

Text Response
Yes the subject was well structured with a focus on how to teach the content, rather than the content itself.
Yes, there were a wide range of activities that were shown that could be implemented in the classroom as well as how to address and rectify students' alternate conceptions.
Yes
Yes
Yes, definitely.
Yes.

Statistic	Value
Total Responses	6

19. Explain your thoughts about the lecturer´s teaching approaches.

Text Response
Our tutor was enthusiastic about physics and this showed in his approaches.
It was a very casual approach in the sense that, while there was a lot of structure, if we weren't able to finish it in the one class, we would be able to focus on the important parts and if there was time later on, to go back and address the points that weren't covered.
He showed that while he had almost all the answers, it was important for me to achieve my own understanding without being directly instructed.
Main intention was to correct student's misconception by applying   Innovative teaching technique.
He used a range of approaches to suit different learner types including group discussions, prac tasks, individual tasks and group tasks. He generally used a range of approaches every class to keep students engaged.

Statistic	Value
Total Responses	5

20. Did you feel lost sometimes during a class? If so, please recall one situation and briefly explain it. How could the lecturer have helped?

Text Response
Some of the discussion problems felt a little beyond me and I had to research a little to get an appropriate answer.
There was one class where we were learning about Van de Graaff generators, CROs and logic circuits. The Van de Graaff generator explanation was fantastic, but the logic board seemed outdated in classrooms, and while I understood the value of them, I didn't really see a purpose. Same with the CRO, but at least I've seen those in classrooms. It might have been the fact that the stations were manned by students explaining about them and their relevance, so it was from the point of view of a fellow student, but there wasn't a lot of guidance as to what we were doing when we were at CRO station.
I don't recall one incident when I was 'lost', but I do recall that sometimes I fully understood the purpose of the teaching after the class had ended.
No not in the class.
There was one lesson in which I felt lost. This was when we were discussion PaP-eRs and CoRes. For the first half of the class I was confused what these were and what they were used for. By the end of the class this became clear, but it might have been good to have a better explanation at the start of the class so I could see where the class was heading. I still do not know why they are called PaP-eRs and CoRes.

Statistic	Value
Total Responses	5

21. Any other comments you would like to make about the Pedagogical Reasoning of the lecturer in this unit?

Text Response
No.
He made it look simple, but gave us the understanding that it isn't!
NONE
none

Statistic	Value
Total Responses	4