Appendix A

Rubric for assessing enacted PCK during the teaching of electromagnetism

Components	Restricted	Adequate	Rich
Curricular saliency	• Never elicits learners' knowledge of pre-concepts • Does not show evidence of knowledge of scaffolding of concepts • No logical sequencing of concepts evident – "jumping around"	• Elicits knowledge of some of the pre-concepts, but assumes knowledge of others • Sequencing of concepts is logical, but omits important ideas. • Effective scaffolding not evident throughout	• Elicits knowledge of all applicable pre-concepts at appropriate phases in the lesson • Shows awareness of the scaffolding of concepts in the topic by referring to pre- or forthcoming ideas • Reminds learners of pre-concepts when these are applicable in the conceptualisation of new ideas. • Teaches key ideas and sub-ordinate ideas with logical sequencing
What makes the topic difficult to teach?	• Does not pay attention to typical difficulties that can arise • Shows no evidence of techniques to address difficulties • Mainly uses (verbatim) repetition to address learner difficulties.	• Misses some indications that learners find a concept difficult to understand. • Attempts to change approach to address the difficulties.	• Breaks down difficult ideas into understandable units that are sequenced logically • Pays attention to possible misinterpretations such as the meaning of "opposed to" in Lenz's law. • Uses techniques such as "slowing down", and a different approach to address learner difficulties.
Learner prior knowledge	• Knowledge of learner thinking not evident • Does not pay attention to possible existing misconceptions (e.g. confusion between magnetic poles and charges)	• Pays attention to some known misconceptions. • Misses some opportunities to address possible misconceptions.	• Pays attention to all (or most) known misconceptions. • Knowledge of learner thinking evident. • Responds to and addresses gaps in knowledge of pre-concepts. • Uses analogies from learners' world to explain ideas

	• Own misinterpretations and misconceptions are evident		
Representations	• Relies mostly on explaining and telling. • The use of representations is restricted to drawings also available in textbooks.	• Use of representations restricted to one type of representation only. • Uses objects as illustrations or artefacts. • Uses a representation with no apparent conceptual development in learners.	• Makes extensive use of representations in combination, e.g. videos and diagrams or demonstrations and diagrams • Uses representations to support understanding of concepts • Uses representations effectively to stimulate conceptual reasoning
Conceptual teaching strategies	• Questions elicits chorus or yes/no responses. • Answers own questions before learners make an attempt. • Ignores learners' answers when not in line with the expected answer. • Does not show awareness when learners reveal the existence of misconceptions • Does not make an effort to incorporate representations to support conceptual understanding.	• Questions asked mostly requires rote learning • Answers own questions after only one or two attempts by learners – does not rephrase questions. • Addresses misconceptions through procedural teaching. • Uses representations in combination with direct instruction – telling learners what they are supposed to see or as confirmation of theory only.	• Shows an attempt to work towards problem-solving and inquiry • Shows creative interaction of TSPCK components • Shows awareness of typical learner errors and misconceptions and works towards conceptual change. • Uses a variety of representations with logical sequencing in combination with appropriate questions. • Asks questions to elicit learner thinking that requires conceptual reasoning • Waits for responses and does not answer own questions; rephrases questions.

Appendix B

Description of the training sessions during the Physical Sciences teaching methodology course

Components addressed	Discussions/activities
Session 1 **Curricular saliency**	Unpack magnetism and electromagnetism from CAPS Class discussion • What is the sequence in which topics are introduced? Why? • Can you identify possible gaps in the content in CAPS - knowledge that need to be in place for certain topics? • Why is it important to understand the curricular saliency of topics? • How can knowledge about the curricular saliency of topics help to transform the knowledge for teaching?
Session 2 **Curricular saliency** **Prior knowledge** **Teaching strategies**	Reading: Saglam & Millar (2006) Class discussion • Magnetism Gr 10 - Knowledge that should be in place before teaching electromagnetism Gr. 11 • Possible misconceptions and other shortcomings in the prior knowledge of learners about basic magnetism ideas • Suggest teaching strategies, approaches and representations to address these misconceptions. • What is a misconception? What is the origin and nature of misconceptions in magnetism according to Sağlam and Millar (2006)? • Identify two misconceptions prevalent in leaners of science regarding magnetism and discuss strategies you will employ to transform the correct knowledge and bring about conceptual change.
Session 3 **Curricular Saliency** **Prior knowledge** **What is difficult to teach?**	Identifying key ideas in electromagnetism (gr11) Class discussion: • What are the key and subordinate ideas when dealing with electromagnetism in Gr11? • What are misconceptions that learners may have when starting this topic and that may arise while teaching this topic? (Sağlam & Millar, 2006; Maloney et al., 2001) • What topics or sub-topics are difficult to teach? Why? • How do topics in Gr 10 and Gr 12 link with the Gr 11 topics?

Session4 **Representations and analogies** **Teaching strategies** **Prior knowledge**	Focus on specific apparatus, practical demonstrations and simulations that can be used when teaching electromagnetism Class discussion: • How can each of the demonstrations be used to support the transformation of content knowledge? Think about: • Aspects to focus on during the demonstration • Important questions to ask and the sequencing of questions • Possible learner difficulties that can be addressed • Possible misconceptions that may arise • Using PHet simulations to teach electromagnetism • Using the right hand to represent the relationship between the directions of vector quantities in electromagnetism • Drawing magnetic fields - How to represent 3D magnetic fields on a 2D writing surface.
Session 5 **Conceptual teaching strategies**. (all of the other four components)	Class discussion: • Think about general strategies for conceptual teaching, • Thinking about key ideas and sub-ordinate ideas in electromagnetism and the strategy that can be used to teach the idea • Considering other knowledge required of the topic and about learners when planning a strategy. o demonstrations and experiments that would support conceptual understanding. o how to explain concepts that learners usually struggle to understand o questions to ask to elicit critical reasoning
Session 6 **Putting TSPCK into practice**	Planning and presenting a micro-lesson about a key idea in electromagnetism