- What are the quality criteria for the design of materials for PD? What are the features of materials for PD that are suitable for promoting IBL and/or more closely connect science and mathematics learning to the world of work?
- Which features do excellent e-learning materials have? How can existing PD materials be modified and adapted for use in an e-learning environment?

Geiger, V. (Australian Catholic University), Mulligan, J. (Macquarie University) — Research-based presentation on material dimension

Creating STEM Online Materials for Pre-Service Teachers Through Interdisciplinary Collaboration Between Mathematics Educators, Mathematicians and Scientists

Monday, 16:50-17:20, Room KA 101

1. Introduction
The purpose of this presentation is to describe processes utilised in developing an online learning program for preservice teachers as part of a significant teacher education project in Australia, Opening Real Science (ORS) – Authentic Mathematics and Science Education for Australia. ORS is part of the national program Enhancing the Training of Mathematics and Science Teachers (ETMST) (2013-2016), initiated in response to growing concern about declining enrolments in mathematics, science and engineering in Australian schools and tertiary institutions. The ORS project draws on the expertise of mathematics and science educators, mathematicians and scientists in a collaboration that aims to enhance the content and pedagogical knowledge of pre- and in-service teachers by structuring the learning of mathematics and science as they are practised – as a dynamic inquiry into the nature of real world phenomena. To this end, ORS has developed 25 online learning modules across mathematics and science. Within these modules mathematical and scientific knowledge is situated within authentic contexts drawn from the experiences of practicing mathematicians and scientists. Consistent with the principle that teaching and learning should mirror authentic practice in these disciplines, enquiry-based pedagogical approaches were considered essential. Students access these modules via a Moodle site that is enabled with a range of online pedagogical tools. Thus, this presentation will address Topic 2 – Material dimension of educating teachers and facilitators: The role of classroom and PD materials and tasks and attend to questions 2, 3, 4, 5 and 6 of the dimension descriptions. This will be an oral presentation within which participants will have online access to selected modules within the ORS project.

2. Background
Falling participation in mathematics, science and technology in Australia has created doubts about Australia's long-term capacity to innovate and compete in an increasingly STEM driven global economy (e.g., Australian Academy of Science, 2016). The root cause of falling participation rates has been linked to students' perceptions of mathematics and science as characterised by didactic instruction and that practical classes are "largely about recipes or watching teachers following recipes" (Office of the Chief Scientist, 2012, p. 9). Accordingly, five key areas were identified as necessary to strengthen mathematics and science teaching in the report Mathematics, Engineering and Science in the National Interest (Office of the Chief Scientist, 2012): (1) Inspirational teaching; (2) Inspired school leadership; (3) Teaching techniques; (4) Gender issues; and (5) Scientific literacy. The principle foci for ORS has been on attention to (1), (3) and (5) of these identified key areas.

3. Conceptual underpinnings
Module development has been underpinned by the Biological Sciences Curriculum Study (BSCS) 5Es Instructional model (Bybee, 2009). This model has been used to structure and sequence all modules

across the project. The 5Es enquirybased approach to science education consists of five phases: engagement, exploration, explanation, elaboration and evaluation. Each phase has a role in developing students' understanding of scientific and technological knowledge, attributes and skills (Bybee, 2009). A summary description of these phases is set out in Table 1.

Table 1. Summary description of the 5Es instructional model (Bybee, 2009, p.8)

Engagement	The teacher or a curriculum task assesses the learners' prior knowledge and helps them become engaged in a new concept through the use of short activities that promote curiosity and elicit prior knowledge. The activity should make connections between past and present learning experiences, expose prior conceptions, and organize students' thinking toward the learning outcomes of current activities.
Exploration	Exploration experiences provide students with a common base of activities within which current concepts (i.e., misconceptions), processes, and skills are identified and conceptual change is facilitated. Learners may complete lab activities that help them use prior knowledge to generate new ideas, explore questions and possibilities, and design and conduct a preliminary investigation.
Explanation	The explanation phase focuses students' attention on a particular aspect of their engagement and exploration experiences and provides opportunities to demonstrate their conceptual understanding, process skills, or behaviors. This phase also provides opportunities for teachers to directly introduce a concept, process, or skill. Learners explain their understanding of the concept. An explanation from the teacher or the curriculum may guide them toward a deeper understanding, which is a critical part of this phase.
Elaboration	Teachers challenge and extend students' conceptual understanding and skills. Through new experiences, the students develop deeper and broader understanding, more information, and adequate skills. Students apply their understanding of the concept by conducting additional activities.
Evaluation	The evaluation phase encourages students to assess their understanding and abilities and provides opportunities for teachers to evaluate student progress toward achieving the educational objectives.

4. An exemplar module

In this section, the processes engaged to develop a module on mathematical modelling, Modelling the present: Predicting the future, is presented to illustrate a typical approach to material development. The module team consisted of eight academics with backgrounds in mathematics, science, and mathematics and science education volunteered expertise in biological evolution, financial mathematics, astrophysics and environmental science as well as experience in the teaching and learning of mathematical modelling and instructional design. The process of module development was collaborative and emergent consisting of four phases: selection of content, identifying structure, and planning for subsequent phases; initial case study development; draft case study review; and finalisation of the module by linking of case studies. Case studies were identified through discussion of contexts that had the potential to promote students understanding of mathematical modelling and settled on the following topics: evolution and transmission of disease-causing agents (epidemiology); effect of market forces on the stock exchange in relation to investment and risk (financial mathematics); nature of eclipsing binary stars (astrophysics); and impact of pollution in waterways (environmental chemistry). This decision led to a subsequent discussion of how to organise the case studies within the module in a manner consistent with the 5Es model and within the constraint of 36-

40 hours of study over 4-5 weeks allocated for a module. The structure the team agreed on was: an introduction; a case study mandatory for all students; a second case study chosen from three options; and a final reflection tied to a capstone assessment. An overview of the module phases and their alignment with the 5Es model appear in Table 2. The module provided a high level of initial scaffolding that was slowly removed with the expectation that students would adopt increasing levels of independence as they progressed.

Table 2. Module phases and alignment with the 5 Es model

Description	5Es Model
Introduction: Description of the process of modelling and its importance. Overview of the unit, learning outcomes and assessment. Examples of how modelling is used to explain phenomena and make predictions (videos).	Engagement
Case study 1 Epidemiology-Humanity's greatest killers: Introduction to the nature of infectious diseases and how modelling can be used to predict transmission rates. Examination of specific epidemics, such as Ebola, to explore the mathematical modelling associated with understanding the spread of disease, based on biological mechanisms Assessment that required students to investigate mortality rates in relation to changes to influential factors in infectious disease spread based via the use of a prepared spreadsheet.	Engagement Exploration Explanation
Case study 2 (choice of Trading-Understanding investment and risk, Environmental chemistry-Impacts of pollutants in Catchments, Astrophysics-Modelling the big, the strange, and the too far to see): While the contexts varied, each case study provided: a description and background to real world scenario and specified an open ended problem within the chosen context; introduced a digital tool (e.g., a prepared spreadsheet) for investigating and responding to the problem; activities designed to promote students' understanding of the scenario, the problem and familiarity with the digital tool; assessment in which students were required to make predictions about aspects of the scenario/problem.	Engagement Exploration Explanation Elaboration
Reflection and capstone assessment item: Students must develop teaching resources for secondary mathematics students in which: mathematical modelling is introduced via a real world scenario; assumptions which underpin the chosen model are described; the model is used to make a prediction about a problem associated with the scenario; the usefulness and validity of the model are evaluated.	Engagement Exploration Explanation Elaboration Evaluation

5. Final Comment

The dimensions of the 5Es model underpin each module within the ORS providing for consistency and coherence across the program. At the same time, the processes associated with module development allow for ground breaking interdisciplinary collaborations among mathematics and science educators with practicing mathematicians and scientists – an intentional linking of perspectives and expertise within the project. Trials of these modules are currently underway with evaluation reports on the effectiveness of modules, in relation to student learning, forthcoming.