

## A Brave New World: introducing the planets online

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There are numerous challenges facing a class at university: limited access to tutorial rooms, fewer tutors and low student attendance in traditional lectures. A further challenge in science is the need to facilitate the learning—and develop the science literacy—of non-science majors, who in the case of this paper elect to study astronomy as part of their academic program. On moving a class online, the challenge includes finding, and becoming confident in using, effective methods and tools. This paper traces a process of review and collaboration between an educational development team and faculty academics to reconfigure an introductory astronomy unit. Part of the approach is to engage students using concept mapping to underpin enquiry-driven pedagogy using the university's learning management system.

Keywords: concept maps, peer instruction, educational design, astronomy, science education.

### The Project

The project started with a teaching development grant in mid 2011 that brought together an Educational Developer (ED), Online Educational Designer (OED) and Convenor. The aim was to investigate how to take an introductory astronomy unit into a blended mode in Semester 2, 2012 and prepare for a wholly online unit in 2013, for students majoring in both science and non-science subjects.

A number of meetings over several months followed a process of sharing issues, perspectives and ideas, leading to a draft plan for the unit. The educational designers needed to understand the Convenor's style, perspective and issues with the unit, as well as her ideas for its improvement, while the Convenor needed time to understand and experiment with unfamiliar teaching approaches, such as the use of concept mapping and the various interconnected technologies which would support individual and group enquiry-based learning.

### The Unit

The Convenor reported a belief that students memorise facts but do not understand the inter-relationships of scientific phenomena. While they could demonstrate knowledge of individual aspects of astronomy, they often struggled to explain how solar systems and planets develop and work in connection with each other. Students had reported trouble dealing with the volume of material covered in the course. Those with a non-science background, in particular though not exclusively, lacked tacit knowledge and carried a measure of naïve misconceptions. Although the Convenor was highly rated by students as a lecturer, many key concepts were not understood sufficiently, resulting in low test scores. The Convenor was already in the process of reducing the spread of content and increasing the depth in which some concepts were explored, but at the same time wanted to develop a framework which would promote active learning.

In end-of-semester surveys, students reported being unhappy with the limited tutorial support afforded by the unit: in a previous year tutorials ran a few times per semester and in 2011 there were none at all. A significant proportion of students did not attend lectures, and the audio recording of lectures was perceived as inadequate

because lectures feature live prop-supported demonstrations.

As a popular introductory course open to students from across faculties, the plan was to make it available as a fully online offering. The unit required a new approach to delivery, student support and assessment.

## **From the Literature**

The aim for the unit was to facilitate deeper understanding. Meyer and Land (2006) describe a threshold concept as one that is likely to be ‘troublesome’ for students to grasp in that it runs counter to their preconceptions, but that can be transformative and ‘exposes the previously hidden interrelatedness of something’ (p. 7). In dealing with threshold concepts, Meyer and Land advocate active learning methods and creative tasks to encourage understanding. It is challenging work to construct new understanding.

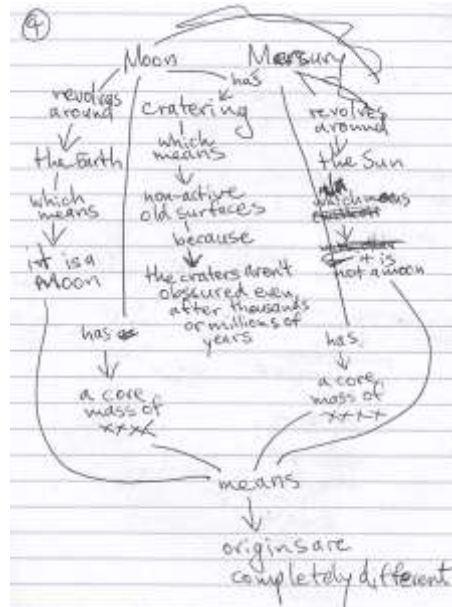
The practical application of constructivism in education has been problematical (Perkins, 2006); it is easier to ‘talk the talk’ than ‘walk the walk’. Perkins highlights the importance of bringing tacit knowledge to the surface by asking students to discuss their ideas, that is, by ‘surfacing and animating’ the tacit knowledge, students ‘play the game knowingly’ (p.40), developing metacognitive skills. More specifically, the teaching of science to non-science majors has been a problem acknowledged by a number of scholars (Prather et al., 2004). Mazur (1997) suggests memorisation tends to be the way students tackle subjects like physics or astronomy, leaving them with little true understanding of the basic laws and concepts. This aligned with the Convenor's observations.

We decided to use in-lecture questioning and concept mapping. Concept maps have been used in a number of introductory university astronomy classes (Newbury, 2010; Zeilik, n.d.). Concept mapping enables students to organise and explicate knowledge, highlight gaps in understanding and provide a shorthand visual representation of non-linear knowledge (Novak & Cañas, 2008). They differ from less structured mind maps by generally answering a specific question and joining concepts by ‘linking words or phrases’, forming ‘propositions’ (Novak & Cañas, 2008, p.1; see figure 2). The Convenor was especially interested in how the maps make student knowledge visible, showing how students’ conceptions develop and helping identify material that might require further support in lectures or through online resources. Concept maps would be constructed in groups, with the associated student-to-student explanations, debates and negotiated answers.

Peer Instruction (PI), developed by Mazur (1997) for the teaching of physics and adapted by Green (2002) for astronomy, involves asking a question that integrates the previous 10-15 minutes of lecture material, where each student answers individually first, discusses with neighbours and then answers again. It is also called ‘think-pair-share’ (Prather, Rudolph & Brissenden, 2009, p.43). The value is in having to articulate the knowledge and hear an argument from someone at a similar conceptual level, rather than passively listen to a lecturer (Mazur, 1997). We purchased clickers to use in lectures to gather responses and to evaluate the type of questions that promote productive results (for example, questions that elicit around 30-70% initially correct answers from individuals (Mazur, 1997; Green, 2002)). When the unit is wholly online, this approach and findings will inform how we set up the online environment. Lecture-tutorials (Prather et al., 2004), in which students work in lectures through a series of problems that build upon each other, may also be adapted for online interactive exercises. The Moodle Lesson module was identified as one possible method for this.

## Our re-development approach

### Example of concept map development in the project



**Figure 1: Initial freehand concept map attempting to answer: ‘The Moon and Mercury look alike, but how are they different?’**

From the outset, the team worked in small stages, with regular meetings to explore ideas and allow the Convenor to experiment with the various elements being proposed - both technological and pedagogical. This process provided a context to critically review existing materials and to assess their potential to be re-used or omitted in the new schema, for example dropping details of some of the gas planets. The review was for relevance to learning objectives but also to consider their discover-ability by the students using the concept mapping scaffold being developed. This strategy was used to reduce the ‘taught’ material such that students are afforded the time to find linkages, gaps and relevance between concepts, ideas and observations.

The Convenor made a journey with the ED on the idea of concept maps. A significant enabler of the project was her openness to exploring unfamiliar educational theories and their relationship to proposed instructional technologies. As educational theory is itself broad and contested, we see constructivism, like Perkins (2006), as ‘more like a Swiss army knife with various blades for various needs’ (p. 45) and worked to apply solutions to our specific situation.

In our process it was vital to include the Convenor as an integral part of the design team. For example, the Convenor developed ten draft questions for the proposed concept map assessment task. The OED, in the role of novice-student, attempted to create the concept maps freehand (figure 1) and then using the free software CmapTools, based on the guidelines of Novak and Cañas (2008), hints from the Convenor and a certain amount of Googling. This proved a good, quick way to test the idea and to give the Convenor a better view of how concept mapping might work. Later, the OED and Convenor worked together on refining the map (figure 2). While this did not mirror exactly the planned peer-to-peer interaction of the assessment task, the experience of talking through the ideas and how to map their relationships was a reassuring confirmation of the value of dialogue in knowledge creation through the collaborative development of mediating artifacts (Paavola & Hakkarainen, 2005).

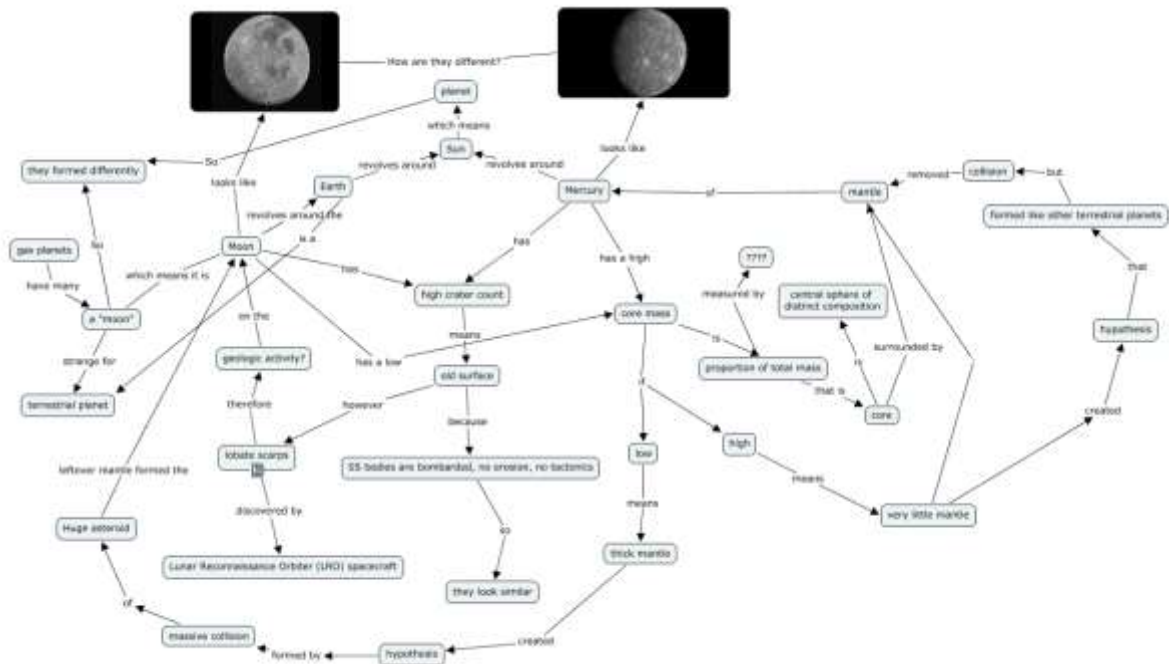


Figure 2: A more detailed concept map created in CmapTools (<http://cmap.ihmc.us/>)

## A sustainable approach

Increased support for students can be achieved through several approaches, including making lectures a little more tutorial-like through peer instruction, teaming students in groups to work on concept maps, formative feedback and through offering online tutor-attended chats at specific times.

There were a number of strategies to enhance sustainability and lower barriers to adoption. One approach was that of minimising the changes needed to lecture material. PI and lecture-tutorials can be utilised with existing lecture materials with minimal work. As there are problems and questions already developed for astronomy, together with guidelines in their use, they won't need to be developed totally from scratch. This is a less confronting or time-consuming way of introducing change, as Lecturers can still use most of their existing lecture material and benefit from the experience of tested methods. The Convenor will not teach the first offering of the unit with the planned changes, so introducing the Lecturers to the fundamentals and bringing them to a level of comfort with the approaches is a further strand to the project.

We aimed to fit activities, marking time and online support for tutorials within available resources, balancing the need for tutor access and feedback with an acceptable budget. Calculations were for a cohort of around 250 students (session 2, 2012 ended up with enrolments of over 400) working in groups of eight, with a non-compulsory weekly one-hour tutorial, repeated four times a week, run by synchronous online chat.

We put the three existing paper quizzes online, using only questions within the automatically marked options available within Moodle, the LMS, removing short answer questions. This freed up some marking time for formative feedback on group work.

A new group project based on concept mapping and pieces of related and reflective writing was introduced, with each group receiving two instances of short formative feedback before final submission. While group work helps manage marking time for large cohorts, we wanted to ensure that groups were given assurance and support in doing the unfamiliar task of mapping. Each student is also required to produce a short reflection on their role in the group project, which gives students a chance to outline their project 'soft' skills and is a source of information for us on how the task worked from their perspective.

## Re-development of learning materials

The default recordings of lectures are audio with computer screen capture. A number of the key concepts in

lectures are demonstrated with props and physical enactments, which will need to be captured on video (which may be ‘quick and dirty’ webcam productions) and/or supplemented by existing or created online animations and interactive questions. It is important that the Lecturers and Convenor are able to create video content themselves. A learning and teaching centre video production support project is developing training and resources.

Support materials for students on how to collaborate, build concept maps and use concept-mapping tools were developed by the OED. They are fairly generic, so can be re-used in other units. The OED has also produced an animation to support the unit’s practical assignment involving mapping the phase and position of the moon over time—a troublesome task that requires some reorganisation of spatial concepts in order to plot on a sky map.

This unit is being delivered in a blended mode in Semester 2, 2012 using online group collaboration and tutorials. In addition, some remote students—and a proportion of on-campus students—are participating without coming to lectures. Another step in the iterative re-development of the unit.

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