Tahi: Encouraging expertise in the way students engage with learning

Keri Moyle, Faculty of Engineering CLeaR Fellow 2015, University of Auckland

What's the problem?

Education in a course-based system inherently requires students to learn material in a defined, linear, sequence of discrete parts which frequently do not refer to one another; it is unsurprising that the structure of student knowledge becomes similarly discretised and linear [Hay et al, 2015]. So while students know *what* we've taught, they also know it *how* we've taught it. If we teach in modules, they will know in modules, if we teach in courses they will know in courses, if we examine frequently they will study (and forget) frequently. There are justifiable reasons for course-based teaching and assessment, and I am not challenging them here, rather proposing that if the *how* of our teaching strategies and delivery so affects student knowledge, then perhaps we must seek a way to change our *how* such that it leads to more beneficial traits and learning behaviours.

Tahi is a software program designed so that way in which digital content is accessed by students promotes expertise, as defined below.

Expert vs novice: what's the difference?

There have been many terms in educational literature used to distinguish the *what* of knowledge from the *how* of knowledge: Ausubel's (and later Novak's) meaningful or rote learning [Ausubel 2000, Novak 2010], Marton and Säljö's deep or surface learning [1976], Jacobson's clockwork or complex systems mental models [2001], the well-thumbed Biggs and Collis' [1982] and Bloom's [Anderson et al 2001] taxonomies of learning outcomes, as well as the idea of the differences between novice and expert cognitive structures [Hay et al, 2007, 2008, 2015].

In this discussion I use the terms "expert" and "novice" to refer to the ends of a spectrum of cognitive structure (thought patterns) rather than experience or time in a field. Here, a novice is a person who – irrespective of their education or experience – has novice-like thought patterns, and likewise an expert has expert-like patterns, to be explained in a moment. Ericsson [2006] tells us that "continued improvements (changes) in achievement are not automatic consequences of more experience", thus it is entirely possible to be a highly educated novice just as it is possible to be a beginner expert; it is ironic that while education desires the latter it usually results in the former.

The schematic in Figure 1 (a) illustrates the two continua of cognitive structure and learning exposure or experience, and shows the familiar student pathway (lower arrow) toward the practised novice and the desired student pathway (upper arrow) towards expertise of any level.

The novice tends to have a linear (or sometimes disconnected) structure of knowledge: for example, knowing how to go from idea A to B to C to D, rather than A straight to D, or any others in any other order. It is a directional, linear structure as shown in Figure 1 (b). In contrast the expert tends to have more complicated relationships between ideas, and is able, for example, to go from B to D via A or even via F, as shown in Figure 1 (c). Note that the expert does not necessarily have a greater *number* of ideas than the novice (that is, she does not necessarily *know more*), but the *structure* of what she does know is very much more complex and inter-related than that of the novice [Hay 2007].

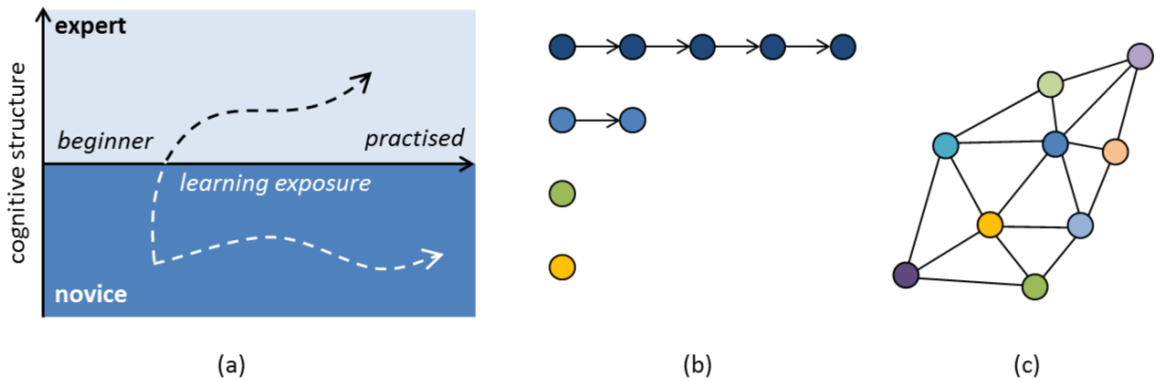

Figure 1: (a) Schematic showing two continua of cognitive structure (from novice to expert) and learning exposure (from beginning to practised), where the upper arrow represents a desirable student learning trajectory and the lower represents the customary student pathway, (b) a representation of a novice knowledge structure where ideas are connected in a linear, sequential manner, and often disconnected from other ideas, (c) a representation of an expert knowledge structure where ideas have many complicated connections and do not rely on a directed sequence.

These differences in knowledge structure create behavioural differences, with novices tending to use mechanistic approaches to problems rather than the adaptable or flexible approaches of the expert. Novices tend to fixate on the superficial rather than the abstract or structural aspects of problems, and experts vice versa [Novick 1982]. It is easy to see how education in a course-based system reinforces the linear and disconnected nature of novice knowledge structures, and it is this situation which Tahi aims to address.

What is Tahi?

Tahi is an online program to assist student learning by encouraging and practising characteristics of expertise simultaneous with the delivery of existing course material. Taken from Maori and meaning (amongst other things), "together, simultaneously, as one, in unison" as well as "first", the name "Tahi" is intended to convey the idea that both the learning *matter* (that is, the substance of subject material and disciplinary knowledge) and the learning *manner* (that is, the connections and organisation of the learned matter) must be addressed together from the beginning if expertise is to be fostered.

Constructivism suggests that the actions of the student are more influential than those of the teacher on the final structure of student learning (the *how* of learning), an idea echoed by the work of Hay mentioned earlier [2015]. Thus, the question, "What do I want student to *have*?" is better framed as "What do I want students to *do*?", though both questions have been used to give the rationale of the program's operational design.

What do we want students to *have*?

Novak [2009, p23] provides a good starting place from which to answer this question, defining the requirements for meaningful learning as:

1. *Relevant prior knowledge: That is, the learner must know some information that relates to the new information to be learned in some non-trivial way;*
2. *Meaningful material: That is, the knowledge to be learned must be relevant to other knowledge and must contain significant concepts and propositions;*
3. *The learner must choose to learn meaningfully: That is, the learner must consciously and deliberately choose to relate new knowledge to relevant knowledge the learner already knows in some non-trivial way.*

Addressing point 2 first, we can be confident in stating that common to every educational situation is the existence of a disciplinary domain in which it sits. Engineers have ideas about engineering, chemists have ideas about chemistry, and painters have ideas about painting. Two aspects of expert performance are the ability to transfer knowledge from one situation to another and to relate ideas to one another; in order to do either of these some (albeit small) amount of knowledge is required in the beginning. It is entirely fitting that one of the answers to "what do I want students to have" is meaningful or domain-based knowledge, but the course structure in which that knowledge is delivered often implies the scope of that domain as "this course" rather than "this profession". It is important that students recognise the domain in which to situate their knowledge, and it is just as important that that domain is a meaningful rather than an arbitrary one. As anyone who's ever had to re-enter a room to recall why they left it in the first place will know, "walking through doorways causes forgetting" [Radvansky 2011], so we as teachers need to be sure – where we must impose walls and doorways on our students' learning processes – that these are in sensible places.

What do we want students to *do*?

An expert behaviour which falls naturally point 2 above is the practice of *abstraction*; that is, the student must first *recognise* that the material to be learned is indeed relevant and of significance, and to understand what that significance is. As a simple example, consider the following question:

> *In her apple orchard, Jenny has five rows of four trees, each with eighty apples. If she picks one hundred apples every day, how long will it be before she is halfway through picking?*

When asked what this question is *about*, the novice might answer "apples" or maybe "apple picking" and look for their own prior knowledge resources and work out solutions accordingly; they have identified the *superficial* rather than the *structural* aspect of the question. In contrast the expert is not distracted by the setting, and would look for solutions related to multiplication [Novick 1982]. A critical part of expertise is the *recognition* of the structural and transferrable aspects of the problem, the identification of the "real" question; in short, *abstraction*.

A second characteristic of expert behaviour is the practice of accessing and using prior knowledge, as mentioned in point 1 above. In our maths example, as soon as the expert has identified that it's about multiplication, he can then use *any* previous experience of multiplication from *any* previous setting to solve the problem. This expert behaviour relies on the domain of knowledge: if, as previously discussed, the domain boundaries are recognised by the student as being "this course" rather than "mathematics", then both the quantity and quality of the prior knowledge they are able to access is greatly limited. Hay et al [2008] found "that students' prior knowledge is a key determinant of meaningful learning", so fostering both the recognition of prior knowledge in the true domain (as opposed to the arbitrary course-based domain) as well as their ability to access that knowledge are crucial.

Finally, and related to point 3, is the idea that the experts recognise the value of *current* learning to *future* situations, and address it accordingly. This is, in essence, a reversal of the second point: if a student is convinced that the *prior* learning above is both accessible and useful in the *current* situation, then it becomes much more likely that he will be able to see his *current* learning as of importance to *future* situations as well.

How can Tahi help?

The student experience with Tahi has been designed such that the three key expert behaviours (abstraction, accessing of prior knowledge, and learning for the future) are implicitly encouraged and rehearsed during the interaction with course material and assessments, both existing and new. The student's capability in each is reinforced using a cyclical structure as shown in Figure 2.

add | Course material (both assessments and resources) are added to the system, either through manual upload or through automatic links to an online content management system (the latter is still in development).

tag | Students are alerted to upcoming assessments and taken through the process of identifying the underlying concepts in their questions. In a process known as "tagging", the student drags a box around an area of the page representing the question they are addressing and selects the most relevant concepts from a controlled list. Currently this controlled list covers material in all undergraduate courses in the Faculty of Engineering and the Faculty of Science, and its concepts number approximately 5000. This step encourages the process of *abstraction* – the first characteristic of expert behaviour – requiring the identification of what the question is *really* asking about before proceeding. The tagging interface page is shown in Figure 3.

find | Resources are supplied based on the student's *own* identification of concepts within the question. This step draws information from any and all previous courses – inherently extending the domain boundaries beyond the walls of "this course" towards a wider and truer representation of the discipline or programme – and includes both course resources supplied by the teacher as well as the student's own notes and previous assessment submissions, all of these in any course. This is shown in the right hand side of the screenshot in Figure 4. The tags in the previous step may be amended if/when the student realises that the resources returned are not appropriate or helpful, allowing instant and relevant feedback on the abstraction and identification in the previous step. This step extends the availability of prior knowledge into all previous courses, encouraging a greater richness and broader domain of relevance for the ideas learned.

use | We make no alteration to the way in which students complete their assessments; they will be finished and submitted for grading in the usual way.

save | The third key item answering the question "what do I want students to do?" is to learn deliberately in such a way that their current situation can inform their future ones. Submitted assessments are automatically saved against the concepts identified in them (indicated by the dashed arrow in Figure 2), allowing them to be discovered as a resource in the "find" step above. In studying knowledge transfer, Novick [1982] found that people were more likely to retrieve information from a *previously solved problem* rather than from *previously learned information*, highlighting two things: firstly, the importance of some kind of application during the learning of abstract concepts, and secondly the need to encourage students to "know what they know" by reminding them of previous learning activities. The previous submissions are shown in the upper right hand side of the "find" page in Figure 4, where students can see both the questions and their own graded answers for each submission.

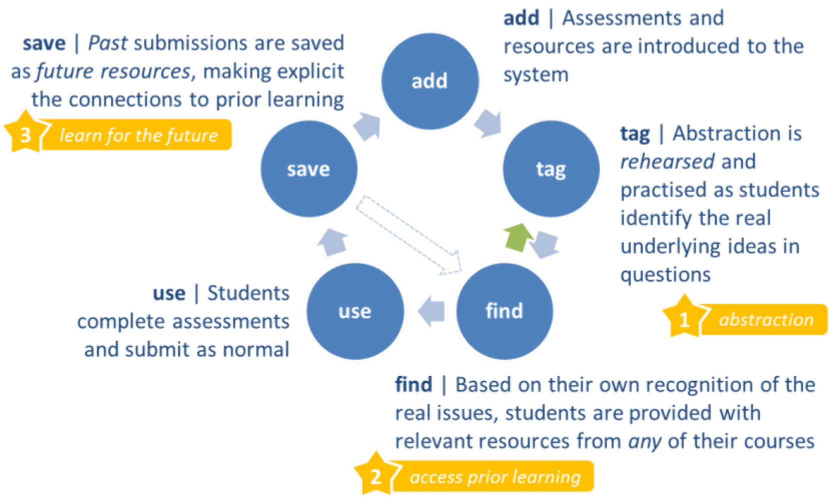

Figure 2: Schematic showing the cyclical stages of Tahi and the students' interaction with it, with the three key aspects of expert learning highlighted where they occur.

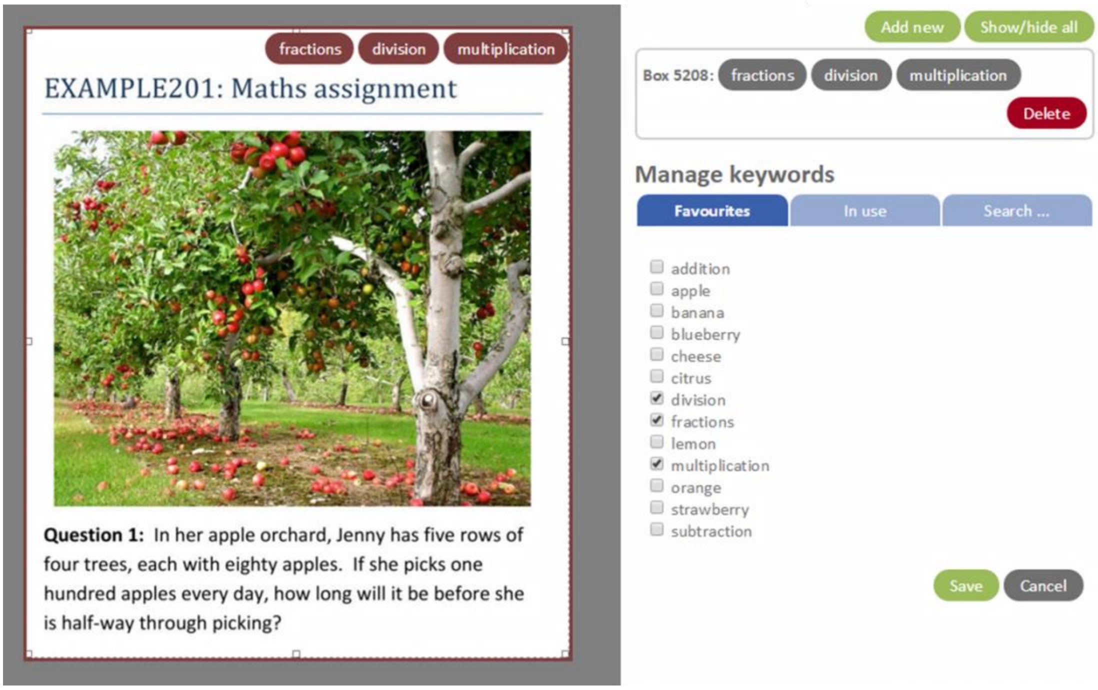

Figure 3: Screenshot of the "tag" page in Tahi. The student has selected "fractions", "division" and "multiplication" as being the what the question is really about.

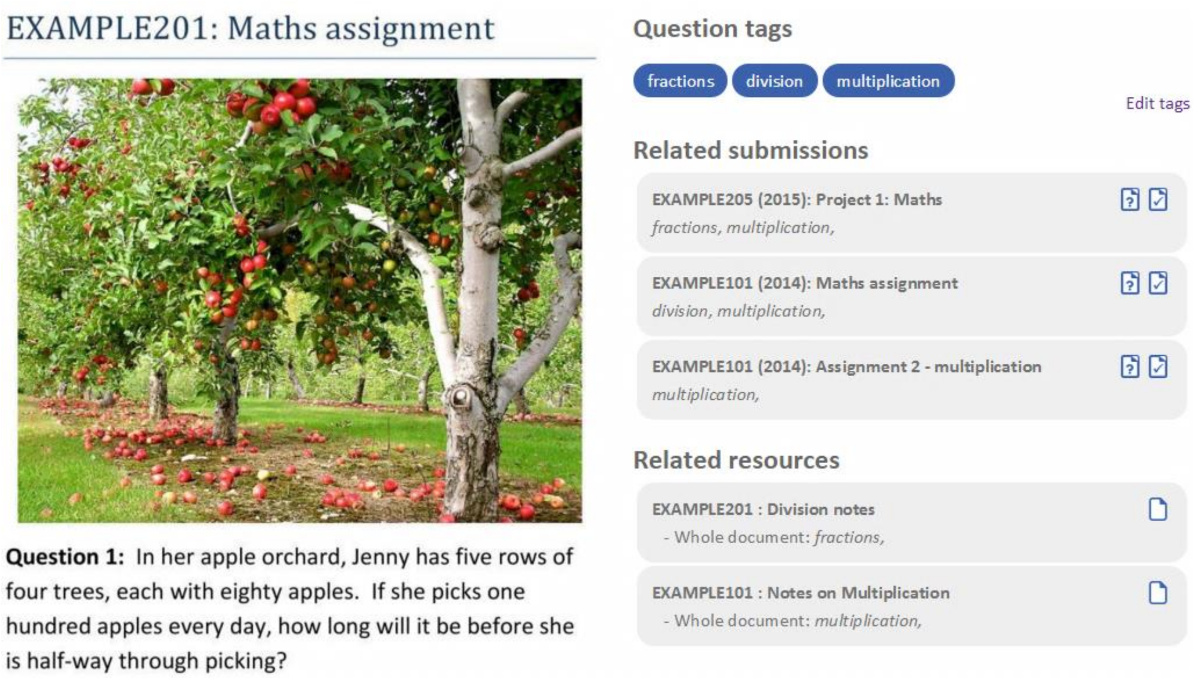

Figure 4: Screenshot of the "find" page in Tahi. The student's abstraction in Figure 3 is carried into this pane, providing them with links to any of their own previous work which is relevant to the current question (both the question and their answers), as well as any resources supplied by the teacher or saved by the student. All information is sourced from any course which the student has taken.

Where to from here?

Tahi will be tested early in 2016 with a small focus group of students. Its cross-course nature means that it must be tested on a *single student* across *multiple courses* rather than within a *single course* across *multiple students*, making recruitment and assessment more challenging than usual. Following this testing (and any adjustments) we will pilot in a larger cohort, with results of these investigations to be reported in the usual channels. Anyone interested in being a part of these tests or discussing the ideas here is more than welcome to contact me.

References

Anderson, LW, Krathwol DR (eds), Airasian PW, Cruikshank KA, Mayer RE, Pintrich PR, Raths J, Wittrock MC (2001) *A Taxonomy for Learning, Teaching, and Assessing: A revision of Bloom's taxonomy of educational objectives*, Addison Wesley Longman, New York, USA

Ausubel DP (2000) *The Acquisition and Retention of Knowledge: A Cognitive View*, Springer Science+Business, Dordrecht, Netherlands

Biggs JB, Collis K (1982) *Evaluating the Quality of Learning: the SOLO taxonomy*, Academic Press, New York, USA

Ericsson KA (ed) (2006) *Cambridge Handbook of Expertise and Expert Performance*, Cambridge University Press, Cambridge, UK

Hay DB (2007) "Using concept maps to measure deep, surface and non-learning outcomes", *Studies in Higher Education* **32**(1):39-57

Hay D, Kehoe C, Miquel ME, Hatzipanagos S, Kinchin IM, Keevil SF, Lygo-Baker S (2008), "Measuring the quality of e-learning", *British Journal of Educational Technology* **39**(6):1037-1056

Hay DB, Proctor M (2015) "Concept maps which visualise the artifice of teaching sequence: Cognition, linguistic and problem-based views on a common teaching problem", *Knowledge Management and E-Learning: An International Journal* **7**(1):36-55

Jacobson MJ (2001) "Problem solving, cognition, and complex systems: Differences between experts and novices", *Complexity*, **6**(3):41-49

Marton F, Säljö R (1976) "On qualitative differences in learning: I – Outcome and process" *British Journal of Educational Psychology* **46**(1):4-11

Novak JD (2010) *Learning, creating and using knowledge: concept maps as facilitative tools in schools and corporations*, 2nd edition, Routledge, Abingdon, UK.

Novick LR (1982) "Analogical transfer, problem similarity, and expertise", *Journal of Experimental Psychology: Learning, Memory, and Cognition* **14**(3):510-520

Radvansky GA, Krawietz SA, Tamplin AK (2011) "Walking through doorways causes forgetting: Further explorations", *The Quarterly Journal of Experimental Psychology* **64**(8):1632-1645