[1]How learners learn : What teachers need to know to be effective

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My presentation examines the issue of what we can learn from the research of how people learn. I have been asked to show what contemporary understanding about learning means on a practical level and in a concrete way for the classroom, for the teacher, for teacher training, professional development, assessment, policy and resource allocation. And in the second five minutes ….

The research on learning is voluminous and growing exponentially. It would take many volumes to summarise. As teachers, it is not only the research that interests us. We are also interested in the theories about learning the research is examining. We want to know how well these theories are supported and validated by research. We want to know what has been shown to work.

We are all aware that a plethora of learning theories exist. We have

- developmental theories
- cognitive theories,
- behavioural learning theories,
- neuropsychological theories,
- psychometric theories,
- sociocultural theories,
- authentic theories,
- biochemical theories,
- immersion theories.

We even have combinations of these;

- social behavioural learning theories,
- cognitive behavioural learning theories.

The theories differ in range of ways. One would suspect that we have a greater diversity of theories about learning than about any other human activity. All claim to be effective, all claim to be based on reputable research.

The majority of them, however, are not teaching-friendly and are not easily contextualised in the world of 21st Century classrooms (or even 20th Century classrooms). As a result, they are not used to inform regular teaching.

Learning involves changing or modifying what one knows. Key questions that underpin an analysis of learning include

- what actually changes ? What parts of our knowledge changes at any time ? How much does it change ?
- What stimulates or motivates the change ?
- What conditions need to be in place for the change ?
- how does a person's knowledge change ? What things need to be done, what actions need to take place for the change to happen ?

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- how permanent is the change ?
  - how long does the change last ? What do we need to do to make it last longer ?
  - does the stored knowledge change 'by itself' over time ? In what ways ?
  - can we cope with a maximum amount of permanent knowledge ?
- how useful is the change in knowledge ?
  - how can we get the most use out of what we know ?
  - does linking it with other knowledge increase its usefulness ?
  - does it need to be learnt in particular ways to be most useful ?

The present approach examines learning from the perspective of knowledge enhancement (Munro, 2001). It is based on the question : What do individuals need to do to enhance their knowledge of a topic ? To answer this, we analysed some of the most popular public domain theories of learning to identify the aspects or components of learning each had validated. We synthesised these into a generic framework that identified what learners need to do to learn effectively.

We call these actions 'learner functions' or learning interactions (Munro, 2002, 2001, 1999, 1997, 1996). They are the actions learners use to transform their existing knowledge at any time. In passing, I need clarify my definition of knowledge; it refers to what one knows and includes one's (1) propositional and conceptual knowledge and the associated procedural knowedge (2) attitudinal beliefs (3) beliefs about learning and how to learn and how to apply one's knowledge (4) world beliefs.

These learning interactions are used when a learner is exposed to information sources such as peers and parents. teachers, on-line learning programs, books and other media sources. In formal education the information sources are determined by what is valued by the community or culture. These values will also be indicated in the feedback learners receive. In self initiated learning, the information is selected according to personal values and may be in part generated by the learner.

To illustrate the learning actions I will use a context in which I was recently involved. My task was to teach a year 3 class how fish breathe.

Learning interactions are what learners do to learn. The set of interactions or learning functions include the following:

1. ***A purpose for learning*** The first interaction relates to learners framing up a purpose or reason for learning a topic. They are 'challenged' to learn, are in a state of 'cognitive conflict' (Lowenstein, 1994). This can range from a largely emotional drive to satisfy one's interest or curiosity to an explicit challenge or question to be answered.

Teacher s frequently need to assist students to frame up goals, for example, learning how to add two fractions.

The fishy activity Look at these two situations.

Here is the Darebin Creek. It has fish swimming around. They are healthy and well. Sometimes people catch some of the fish at take them home for dinner.	Here is the Darebin Creek. It has very few fish. They are sick and dying because they can't breathe. swimming around.

You need to do something to help the fish to survive. You need to help them breathe better. How will you can make the creek better for them ?

2. ***The outcomes of the learning*** The second interaction involves the learner forming an impression of the outcome of the learning, They visualize the desired outcomes of the learning. They form an impression of where they will end up, what they will know, be able to do or what they may believe or feel. They 'see' the goals as personal experiences

(Locke & Latham, 1990; Pintrich & Garcia, 1991). This gives them a direction or focus of their learning.
Teaching often doesn't encourage students to do this. Instead, it operates by giving them 2 or 3 pieces of jigsaw at a time but not letting them see what the outcome will be like. The students can understand each piece but aren't given the opportunity to see how the bits will fit together, what the overall outcome will be like. This forces them to be dependent on the teacher, limits their self management and control and leads to beliefs about helplessness in learning.

The fishy activity Students imagined the outcomes of learning how fish breathe. They can imagine what their finished project will look like. What will they say in it ? What might they know when they have learnt this topic?

3. ***What learners know about the topic*** Learners make links with and use what they know about the topic. Knowledge change begins with what students know that is relevant. This interaction involves are several aspects.

- One aspect is what they know about the topic. Students can have their knowledge of a topic stored in a number of ways;
  - in abstract, verbal ways
  - in imagery ways as experiences and
  - in action ways.

  A plethora of studies have examined the multiple ways in which learners can know a topic (learning styles, for example, Riding & Cheema, 1991; multiple intelligences, for example, Gardner, 1995, 1999; dual coding theory, for example Paivio, 1991).

  The fishy activity To stimulate students' existing knowledge about how fish breathe

  - What do you do when you breathe ? Imagine you have been shrunk and you are travelling in a bubble of air your friend has breathed in. Where would you go ? What would you see ? Where does it stop ? In small groups students compiled a picture showing where the air goes ?

  - In a 'think-pair-share activity, students listed the words they thought of when talking about how they breathe (such as throat, lungs, blood, every part of the body). What actions do you do when you breathe ?

  - What happens when you run fast ? They reviewed how their breathing changed when they engaged in exercise. Practise breathing ? Breathe fast/ slowly. They did and described the breathing action.

  - Review : mouth –throat-lungs –blood –all parts of body

  - They imagined how their pets breathed and thought about the question : Do all living animals need air to stay alive ?

  - How do fish breathe ? Imagine a fish swimming in water ? How does it breathe ? What things might make it hard for you to breathe ?

- A second aspect relates to what they know about how to learn it, how to think through the topic. Again, many studies have examined what students know about how to transform their knowledge (spectrum of approaches to learning, for example, Biggs, 1987; Davidson & Sternberg, 1998; Jausovec, 1994).

  The fishy activity For our fish breathing activity, the students said how they would go about learning a topic, what they would do, and how they would direct and focus their

learning activity. If students say what they will do before they do it, they are more likely to do it.

- A third aspect relates to what they believe about themselves as learners of the ideas, how they value the ideas, whether they believe they can learn the topic successfully (their self-efficacy, for example, Nichols & Utesch, 1998; Pajares, 1996). Learners' self efficacy judgments have an important influence on how they go about learning, the effort they invest in learning and the learning strategies they use. They make these judgments quickly and unconsciously and independently of their actual level of ability.

  It is critical that teachers optimize students' self efficacy judgments before they begin to learn a topic. Teachers can do this by having students identify explicitly what they know about the topic, that what they know is valuable, that they are already 'on the way' and that they know how to learn the topic.

  The fishy activity For the fish breathing activity, the group saw that it had a good deal of knowledge about how other animals breathed. They also saw that they knew what to do to learn about fish and breathing.

- A fourth aspect relates students' beliefs and metaphors for learning and teaching (Pitrich, Marx & Boyle, 1993), what learners do and what teachers do. You can imagine a situation in which a group of students may believe that their role as students is to sit back and be programmed, that learning involves being told, while their teacher requires students to learn by questioning, taking ideas apart and building. You can also imagine the reverse situation where the teacher believes it is the student's role to passively receive the pearls of wisdom, while some of the students want to question and analyse what they are learning. In both cases the metaphors held by the students and teachers are likely to clash and most likely lead to discipline and engagement problems.

- A fifth aspect relates to students identifying what they don't know about the topic. They identify their unanswered questions about the topic.

  The fishy activity For fish breathing, students brain-stormed the topic in small groups and noted some questions they weren't sure of about how fish breathe. What will you do to learn more about how fish breathe ?

They may recode what they know about the topic to a form that they believe will match the teaching. A learner who believes that the teaching information will largely require the use of imagery may recode an abstract understanding of a topic to a set of images or episodes.

4. ***A pathway to the goal*** Learners build or "see" a possible pathway to their goal. This is a critical aspect of successful learning. Students who can see a possible pathway are more likely to maintain engagement and perseverance. While the pathway that learners will follow may change direction during the learning activity, at any time it assists in orienting the learning.

Learners need to have the experience of planning and developing their pathways through a topic. Often they can learn it best by identifying the learning pathway they have followed over the previous few weeks.

More generally, students who see learning a topic as being on a journey through the topic

The fishy activity For fish breathing, the students discussed the following questions

- What will you need to do to finish your project ?
- What extra things do you need to learn ? What questions might you need to answer ?

5. ***Learn in specific contexts*** Learners learn the new ideas in specific contexts in limited, supported, 'scaffolded' ways by linking what they know into new ideas. They make new links between ideas they already know.

They do this in different ways.

- some make small, sequential links between ideas, while others make larger, wholistic links. This distinction is important in teaching. It is shown in the following:

Serial - analytic strategies	Synthetic-global strategies
Work on bits of information	Look for overall patterns, scan,
Learn step by step, delay giving answer	Leap in and answer quickly, guess impulsively
Focus on detail and specific facts	Focus on overall idea, miss or ignore detail
Think in one direction provided by teacher	Think by moving in several directions at once
Take things apart, work on the parts	Think in wholes; don't take things apart
Follow other people's directions well	Prefer to direct, manage their own learning flexible in their thinking, unanswered questions.
Prefer less flexible convergent learning	Prefer flexible, open-ended learning contexts
Learn other's explanations, procedures	Prefer to work out own explanations
Analyse, sequence ideas in learnt ways	Arrange, sequence ideas less predictably.
Reflect about an idea often for a long time	More likely to 'guesstimate'

- some may link ideas in time and space in specific contexts; they form images episodes or experiences of new ideas while others link ideas in more verbal, less contextualised ways. They form relationships between ideas in familiar language. Others link them in action sequences.
- think intuitively about the ideas, explore and trial particular components and then use context-evaluative thinking.
- ask questions that bridge from existing to new ideas *How can we get from..to .. ?* These question sequences allow them to move gradually from what they know.
- recode imagery, action knowledge of new ideas into words.
- practise new ideas.

The learning process at this point draws on and integrates contemporary learning research from a range of sources: the role of imagery in learning, multiple ways of learning (for example, Paivio's Dual Coding theory) , learning through internalised actions or operations, learning through specific episodes (Tulving's work) , the role of short term working memory in learning (Baddeley's work) and the work of information management for learning.

This interaction is frequently overlooked or ignored in conventional teaching. Teaching expect students to learn new ideas in an abstract, decontextualised way initially and then learn to apply it in particular situations later. While this is frequently seen as an efficient way of teaching, it is not as likely to lead to effective learning.

The fishy activity For fish breathing, the students examined specific instances of fish breathing, for example

- watched videos of fish swimming. Are the fish coming to the surface to gulp in air ? What do they do as they swim ? What would happen if they tried to breathe through their nose ? Where is the air you will breathe in a minute ? Where is the air that fish breathe? How do they get it out of the water ?

- inspected dead fish; identify the gills and the fins.
- imitated how fish move as they swim.

Students investigated each scenario, and

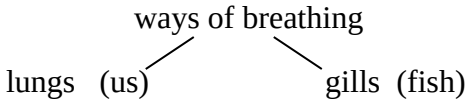
- heard / read about how fish breathe, situations in which they have been helped to stay alive, visualised and discussed the story, paraphrased the key ideas.
- learnt the key terms relating to how fish breathe
- learnt the actions that fish use to breathe.
- recorded their new knowledge about fish breathing in notes, pictures and showed what they thought.

6. ***Abstract or deepen the new understanding.*** Learners deepen their new understanding. They abstract or "decontextualize" it, and link it more broadly with what they know. They

- link episodic, verbal and action aspects of idea at once ; they say, write, draw, do.
- review, consolidate what they have learnt with what they knew
- decontextualize, summarize, re-organize, re-prioritize, main/subordinate ideas.
- elaborate and extend ideas through questioning.
- teach the conventional ways of communicating new ideas
- identify a range of contexts in which they can use it.

The fishy activity For fish breathing, the students generalised what they had learnt about how individual fish breathe. They

- linked episodic, verbal and action aspects of how fish breathe ; said, wrote, drew, did 'fish breathing.
- examined whether all fish breathe in the same way and how fish that don't have gills breathe, categorised fish on the basis of how they breathe, selected the main ideas.



- elaborate and extend their understanding through questioning, for example,
  - "When would it be hard for fish to breathe ?"
  - "Would fish be able to breathe better swimming closer to the bottom of a river or sea, near where the plants grow, or closer to the surface because the air rises ? Would you catch fish better if your line was just below the surface of the water ?
- learn the conventional ways of communicating new ideas. They reviewed the key words such as gills, fins, dissolve, blood.

7. ***Invest positive emotion in the new knowledge*** Learners need to invest positive emotion in the new knowledge they have learnt. This increases the likelihood they will

- be self-motivated to think about it and use it on later occasions,
- believe they can learn the ideas successfully and
- believe that it is OK to take risks.

To make this emotional investment in the knowledge, learners need to see

ß the new ideas as interesting, have a value or use,

ß that is was their mental activity that learned the ideas and

ß that they managed and directed aspects of the learning(Zimmerman, Bandura & Martinez-Pons, 1992).

Many classrooms are emotionally sterile. Students are not given the opportunity to make an emotional investment in the knowledge they are learning. They don't see this as an expectation and as well they don't learn how to do this. As a consequence, they frequently lack an emotional commitment to or feeling for the ideas they are learning. Those students who don't do this spontaneously and automatically are often less motivated to learn related ideas in the future.

The fishy activity For fish breathing, the students commented on the value of what they knew now and discussed how they could use the new ideas. They also decided that it was their knowledge, that they did the learning, they could make work for them. They saw that it was them who did the learning and that the new knowledge was in their heads.

8. ***Store what they have learnt in memory*** Learners store what they have learnt in memory and practise remembering it (Baddeley, 1990). They say briefly what they have learnt, link it with what they know, build memory "icons" for it and practise recalling it.

Storing what has been learnt in memory and practising to recall it is a critical aspect of knowledge management and enhancement.

The fishy activity In terms of learning about fish breathing, students can learn to

- Say as briefly as you can what they have learnt about how fish breathe
- Describe how it is similar to /different from what you knew about how animals breathe ?
- Picture in your minds a fish breathing
- Imagine yourself remembering the ideas.
- Drawing an icon of the main ideas to remind yourself.

9. ***Identify how they learnt*** Learners identify how they learnt, what they did that helped them to learn. This includes both the learning strategies they used and the metacognitive control they exerted over the learning. They reflect on and review the actions they used to learn.

This allows students to build up, in an explicit way, their knowledge of how they learn and the learning strategies they can use. They can compile a list of 'What I can do to learn'. They also learn the language for talking about what they do when they learn.

The fishy activity For learning how fish breathe, students examine the question What things did you do to help you learn about how fish breathe ?

- Making links between ideas.
- Making pictures in my mind.
- Thinking of differences between us and fish.

This interaction is important if students are to learn to be autonomous learners, to learn to manage and direct their own learning and to be 'life long learners'.

10. ***Making progress as a learner*** Learners see themselves making progress. There is a range of ways in which students can learn to do this. They can decide what are reasonable signs or indicators that they are learning more about a topic and are making progress. They can use their indicators of learning to map and to monitor their progress.

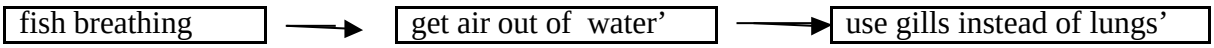
The fishy activity In relation to fish breathing, the students can examine

- What questions they can answer now that they couldn't answer earlier ?
- What they know / understand that they didn't know /understand earlier ?
-

The students decided that they needed to understand first how they breathed and then how particular fish breathed. It was acceptable for them to understand how particular fish breathed initially and then gradually extended this.

11. ***Automatise what they have learnt*** Learners automatise aspects of what they have learnt so it can be used for further learning. They do this by automatizing links between ideas and organizing what they know into larger "chunks".

The fishy activity The students worked on linking fish breathing with 'getting air out of water' and 'using gills instead of lungs'. They drew these links as follows;



The aim here is that one of the ideas , for example, 'fish breathing' stimulates the related or linked ideas.

12. ***Transfer and generalise the knowledge*** They transfer and generalise the new knowledge. They explore and analyse the new understanding from a range of perspectives. They

- explore and analyse the new understanding from a range of perspectives, , for example, use Bloom's levels of questioning, de Bono's Six Thinking Hats, Taylor's Multiple Talents Model
- transfer the ideas (near and far transfer)
- use the knowledge in open-ended creative problem solving.
- create new episodes for the ideas.
- categorise problem solving contexts in terms of whether the ideas are useful
- answer higher-level Bloom-type question sequence
- look at ideas from various angles,
- suggest questions the new ideas answer.

The fishy activity In terms of the fish breathing, the students

- explored and analysed the new understanding from a range of perspectives, for example,
  - Would the gills in all fish have the same shape ?
  - Do bigger fish have more gills ?

- transferred the ideas (near and far transfer). Would a fresh water fish be able to breathe as well if it
  - swam into deeper water ?
  - swam into warmer water ?
  - swam into sea water ?
- What fish might be more likely to survive in 100 years ?

- categorised problem solving contexts in terms of whether the ideas are useful
  - Why is it harder for fish to breathe in muddy water ?
  - How would dangerous chemicals in the water affect how well fish breathe ?

- used the knowledge in open-ended creative problem solving: They were asked to work in pairs or groups of three and were given the challenge : *You are member of committee advising the Darebin Council about what steps to take to stop the fish from dying in the Darebin Creek. What would you suggest the council do ?* The groups, over ten minutes, came up with a number of possibilities :

- Pump air into the creek; this group drew a picture of pumps pumping air into the creek at various points.
- Put air into water under pressure and put it in river
- Keep water cool; have water coolers ; this group drew a picture of the creek flowing past big coolers.
- Make the creek salt water and put in sea fish; this group thought of converting the freshwater creek to sea water.
- Grow plants in the water
- Breed special fish that need less air to live
- Give fish places where they can be safe from fishermen
- Make 'air spaces', 'air bubbles' in the water
- Put pipes into the water that allow air to get into it
- Slow release air tablets.

The students valued hearing about the ideas that other groups had. Each group then agreed to draw a poster showing their suggestion.

- created new episodes for the ideas. In the future the world may need fish to grow faster. Imagine what fish that grew faster would look like.

13 ***Organise what they have learnt for assessment*** They organise what they have learnt for assessment purposes. They reflect on the context in which they need to display and apply the knowledge, how they can align the knowledge with various assessment context.

This interaction is the 'flip –side' of assessment. Rather than focusing on procedures for what students know, it examines how students can learn how to show best what they know. It encourages students to reflect on how they will show what they know and how they can 'read' assessment situations'.

More generally it focuses on how students can learn how they can use their knowledge.

Teachers can implement a range of activities for students to learn this interaction, for example

- Having learnt a topic and needing to show what they know, students can practise identifying what they think they need to do to convince their teacher that they have learnt it, allowing students alternative ways to do this

- Having students in small groups make up 'mock tests' for a topic. Each group of students reviews the content and invents easy and difficult questions for another group.

- Having students attempt to link questions with a topic on which they will be tested. When they are working through the test situation, they can see how much easier it is to link questions in their mind with questions on the test paper.

The fishy activity For fish breathing, the students showed their understanding by

- Working in small groups to design and write a poster that showed what they judged to be important to say about how fish breathe.

- Talking individually to the class about one aspect of their group poster; each student selected one aspect and made a class presentation for about 1 minute.

- Working in small groups to make up a quiz of 5 questions for another group, who assembled and wrote their answers to the test.

- Working individually to select what they judged to be 10 important questions about how fish breathe. Each student wrote a list of the questions and their answer to each.

There are a few points I would like to make about how the set of interactions operates.

The interactions are not a linear one-directional sequence First, the set of interactions do not operate in a linear one-directional sequence. They can be categorised into three clusters: those to do with

- orienting one's knowledge (that is, 'getting it ready') for learning;
- changing one's knowledge and
- consolidating and transferring the knowledge change.

Within each cluster, two interactions may share a reciprocal or bi-directional relationship at any time. As well, in line with parallel information processing theories, knowledge from two or more interactions in a cluster can be processed simultaneously.

The set of interactions are generic. Second, the set of interactions are generic. They are not based in particular topics or subject areas. One of their values is that they can be applied to what one knows at any time to change what one knows. Imagine watching a three year old learning about a new toy. The infant will show evidence of putting in place each interaction. Even though the 3-yearold may not explicitly vocalize the challenge, we can see it in the child's intent –oriented behaviour. Think of any of us venturing onto the Internet tonight to learn more about self efficacy. We will do the same.

What changes during children's development is how they learn to use each interaction. Each interaction involves a range of reasoning and cognitive strategies. As we learn to use these more efficiently, our knowledge changes and so does our ways of thinking about it. We know from the work of Vygotsky that much of what individuals learn begins as knowledge in one's culture for solving problems and communicating.

Each learning interaction is a thinking strategy Third, each learning interaction is a strategy that individuals can use to modify or enhance their knowledge. They help us see how we can improve or enhance knowledge, what we can do. how to convert efficiently information to knowledge, particularly in problem solving contexts and then enhance it. They provide an explicit, systematic framework for transforming knowledge. Much of the current discussion about knowledge management and enhancement is rhetoric; it is not operational. The interactions allow us to operationalise knowledge management and enhancement.

The sequence can become useful 'self talk'. Fourth, the sequence can be used to can be used the to teach students how to learn explicitly, to guide their thinking, learn relevant 'self talk'. They help students learn to be self managing and self directing learners. A key concept in contemporary learning theory is self-regulated learning and self-directing learners (Boekarets, 1997). This competence is managed through 'self talk' or 'inner language'. Learners acquire 'self scripts' that they use to manage and direct the range of activities necessary for effective learning, that is, by improve their metacognitive knowledge. Components of self-regulation include motivation to achieve and students' goal orientation (Pintrich & Garcia, 1991). The capacity to learn this competence is influenced by students' ability to reflect, personal goal setting and academic attainment (Zimmerman & Schunk, 1998).

The interactions actually tell the students what they tell themselves to do when they are using on task attention strategies. Below is a possible set of self scripts these students could learn to use to direct their attention.

- What question do I need to answer here ?
- What will I end up with ? How will I know when I have finished ? What will I have ?
- What do I know about this topic ? What pictures come to my mind ? What words do I think of ?

- How will I say what I have learnt ? What did I do to learn other things like this ?
- What do I know now that I didn't know earlier ?
- Whose brain did the learning for this ?
- What things helped me to learn ?
- What things helped me learn this ?
- What progress have I made ?
- How are new ideas like what I already knew ? How are they different ?
- Where else could I use these ideas ?

In other words, the set of learning functions can be learnt as a set of self scripts that students use to guide their learning in any context. The self scripts can catalyse learning or 'trigger' each interaction. They can also lead to learning becoming a conversation that learners have with other learners, the teacher, or ' themselves', that is, 'reflection during learning'. Given that a major way in which learners learn in conventional classrooms is by 'doing tasks', there may be a need in the future to help students learn effective self scripts for having conversations about and with the tasks they are doing.

A long term aim of the teaching can be that students learn to use the sequence spontaneously and selectively as part of their self talk whenever they need to work through a learning task. Teachers can remind them to talk about what they do when they use each strategy, to evaluate their usefulness and decide when to use them. Students can write the strategies on small cards and use these to self cue. The practice students gain in using the self scripts can be broadened to improve self-control more generally.

So far the focus has been on teachers implementing teaching that encourages and fosters each of the interactions. It is also possible for students to learn to use them explicitly, to guide their learning and thinking activity when, for example, they engage in on-line multi-media learning.

The set of interactions can be implemented in conventional learning at a number of levels simultaneously. As well as individual students learning by implementing them, each student can be contributing to the knowledge of a small group and each group contributing to the knowledge of a class.

How teachers can use this evidence base to teach more effectively

Part of my brief for this session was to discuss how teachers can use this evidence base to teach more effectively. I would like to describe various ways in which teachers and schools have used the framework.

1. Using the framework to improve teaching. Teachers have used this framework to improve their teaching by

- explicating, reflecting on and up-dating their personal beliefs about learning,
- understanding how their students learn and
- developing teaching procedures that foster the learning interactions.

The framework provides a skeleton that teachers can use to integrate their emerging knowledge of learning (Munro, 2002, 2000, 1999). To reflect on your practice in a constructive evaluative way, you need to have a set of criteria to evaluate against. The framework provides this.

I have worked both with schools with teachers to assist them to evaluate their teaching, see how well it (1) matches how students learn and (2) triggers or fosters each interaction.

Some teachers have implemented a self improvement program by audio-taping a sequence of lessons and evaluating the extent to which their teaching fosters each learning interaction. They can improve their teaching by identifying the interactions their instruction is/isn't including and fine-tune /modify the teaching accordingly, for example, to accommodate changes in approach to learning.

How often does your teaching help students	Never	Not often	Some times	Often	Al-ways
• develop a map of where their learning will go ?	o	o	o	o	o
• to be challenged to learn the ideas ?	o	o	o	o	o
• see at the start of a lesson what they will learn ?	o	o	o	o	o
• stimulate their existing episodic knowledge of a topic ?	o	o	o	o	o
• stimulate their existing abstract knowledge of a topic ?	o	o	o	o	o
• match their existing knowledge with the teaching information ?	o	o	o	o	o
• use their thinking space most effectively ?	o	o	o	o	o
• take account of their beliefs about learning ?	o	o	o	o	o
• help them learn new ideas in a range of ways, cue them to think about ideas in different ways ?	o	o	o	o	o

Teachers have also used it to coach and mentor colleagues (Munro 2000). The coach and the teacher identify the learning interactions already effectively in place and those that could be improved by fine tuning the teaching procedures.

2. Teaching can also be improved by getting feedback from students. Students can evaluate the teaching in terms of the extent to which it fosters learning. Teachers can also develop a questionnaire to obtain feedback from students in relation to how the teaching helps them interact effectively with the information presented.

How often in this class	Never	Not often	Some times	Often	Al-ways
• can I see what I will end knowing ?	o	o	o	o	o
• feel challenged to want to learn the topic ?	o	o	o	o	o
• do I see that what I already know about the topic is useful ?	o	o	o	o	o
• am I encouraged to use my imagination while I am learning ?	o	o	o	o	o

3. Map into teaching procedures. We have mapped the set of interactions into an extensive set of teaching procedures, to develop teaching procedures that foster /trigger each learning function. Teachers can organise their teaching in terms of the learning functions. Clusters of teaching procedures match and support each function.

4. Teaching students how to be self managing and regulating learners Teachers have used the model to teach their students how to be self managing and regulating learners by teaching, systematically, the learning interactions as student self –talk. Students can learn to ask themselves the above set of self instructions as self scripts (Munro 2001, 2000).

Teachers have used the model to cater for multiple ways of learning in their teaching.

5. Accounting for multiple ways of learning The framework provides a procedure for accounting for multiple ways of learning at each phase of knowledge change (Munro, 1995, 1999, 2001). It allows teachers to take account of the fact that different learners display each function in different ways. Individual difference and learning style have an impact on each of the interaction. Learners differ in how they

- are motivated to want to learn

- engage with the teaching information and make links with what they know
- display what they know
- use corrective feedback throughout the learning
- change what they know
- store what they know
- automatise what they know

6. Plan teaching units To devise and evaluate instructional and curriculum units that match the various learning functions. The framework provides a useful set of criteria for evaluating teaching units and programs from a learning perspective and indicates types of features that may be included in the design of teaching units.

7. Analyse student learning problems from an 'effective learning' perspective. To analyse how students are operating from an 'effective learning' perspective. It helps us see which key learning aspects are not used by a student or group and how they can be developed. We have used it to benchmark, review and evaluate teaching from a learner perspective. This is an important issue in contemporary educational provision.

Certainly from a learning perspective students find teaching based on the interactions easier to learn from and also more demanding of them. We have researched how students evaluate teaching based on the interactions as opposed to more conventional teaching. Several students actually articulated that the interactions showed that the teacher believed they could learn..

It helps us deal with problems in teaching such as lack of student engagement, behaviour problems, by describing them in terms of learner interactions J. (Munro, 1996).

The learning interactions helps us to interpret the problems learners show from a learning perspective and solve them in terms of pedagogy. Teachers can use it to examine both

(1) how students are learning and the learning interactions they are using and

(2) the learning interactions fostered by the teaching.

We have used the set of interactions to diagnose problems that arise in teaching. We have attempted to link typical learning problems with the teaching procedures that are most likely to reduce the problem. You can interpret the problems learners show in terms of learner interactions and solve the problems from a learning perspective.

You can look at individual students or small groups in whom you would like to foster more positive learning and estimate the extent to which they at present implement each interaction .

key learning functions: The student	Student
has an explicit purpose or reason for learning the ideas, for changing what is known	
has an impression of the outcome of the learning	
• links the new information with what is known • believes she /he can learn key ideas successfully • has positive emotions linked with what she/he knows about topic • knows how to learn in formal contexts • can recode what she /he knows to match the teaching	
knows how to learn effectively in specific contexts	

can decontextualise / abstract the new ideas	
usually responds positively emotionally to the ideas learnt	
learns the strategies to learn successfully	
sees her /him self making learning progress	
encodes efficiently the new idea in long term memory	
transfers and applies ideas in a range of situations	
automatises them	
practises organising the knowledge for display in assessment contexts	

You can see which key learning aspects are not developed, how they can be developed and if they are not, the problems that might ensue. Some of these are shown in the following table.

Successful learning is most likely when learning problems and difficulties are reduced. Links between particular learning interactions and typical learning problems, shown in the following table, indicate how learning may be unsuccessful if particular interactions are not fostered (Munro, 1997).

Interaction : learners	If interaction isn't fostered, students
frame up challenge to learn	• have no reason for learning • see no sense in learning, not interested • can't see how to motivate themselves, if not self-motivated • are less likely to see learning this topic as a priority • are less likely to be excited or satisfied when challenge is resolved
see where they will end up / be able to do	• have nothing at which to aim the learning, the learning is 'aimless' • are easily distracted from learning path
use what they know about the topic	• don't link what they know with the teaching, seem to lack knowledge to interpret teaching • teaching doesn't make sense, fit with what they know • can't get a foothold or get started • believe they know nothing about topic • don't know how to break up information, how to manipulate it • don't know what is expected next, can't predict, infer, take a risk or guess

The learning allows us to link student knowledge and curriculum in a practical, operational way. Pedagogy that takes account of how students learn optimizes both knowledge enhancement and our understanding of knowledge. C 21st students live in an information rich context and need to know how to enhance their knowledge of a topic by accessing information sources. The set of interactions provide a starting point for learning this.

I recently worked with a Year 8 class given the challenge of designing an improved carton for holding fresh milk to be sold in retail contexts. They used the set of interactions as a pathway to guide their thinking. They framed up their challenge and identified the questions they wanted to

answer. They generated impressions of where they wanted to end up, what they will know. They used their existing knowledge to shape up questions to ask about desirable shapes, flexibility (not breaking or rupturing), whether there is a need for it to be insulated re heat or light, its ideal weight, aesthetic features.

We have also used the framework to examine how schools are learning communities can actually learn and enhance their core work by using the learning framework. The model is showing that it is just as effective in operationalising the learning of professional groups as it is for classroom practice. One issue we are examining is how professional learning in schools can be facilitated by equipping some staff to operate as 'middle level leaders of learning'. For the most effective learning, these leaders need particular skills to lead the learning of the group.

To summarise, let us return to our original question. What, to be effective, do teachers need to know about how students learn? As a minimum, I suggest that teachers need the following areas of knowledge :

- An explicit integrated understanding of learning links curriculum with student knowledge and bridges from the present to the future.
- Contemporary theories of learning can be operationalised in teaching practice in systematic and consistent ways and give a focus on 'explicit learning'.
- The set of learning interactions provides a framework for (1) understanding and fostering student learning, (2) for implementing effective teaching, and (3) for enhancing the quality of learning and teaching at the classroom and at the learning communities levels.
- Contemporary theories of learning can help you plan, implement and evaluate teaching that indicates to students that you believe they can learn and that you expect them to learn.
- You can teach students how to be self managing and directed learners more easily. As one student said recently, the learning interactions help you be like a book worm eating your way through a book, except that you are learning your way though a topic.
- With the rapid changes in how students learn in recent years, our practices need to have the capacity to be informed by theories of learning.
- Our data bases that drive teaching need to take account in part of data and information from the learning process domain and not only from the learning outcomes. The learning outcomes should not be seen as ends in themselves but as the ends of learning processes that can be modified.

Linking the interactions with what brains do.

This set of actions leads to learning. They have the capacity to change the structure of our brain. A recent trend in learning is to synthesise neuropsychology with how we learn. Scientists have linked how the brain operates with how we think. Improved neuropsychological procedures such as brain mapping, have allowed us to monitor and track what learners do as they manipulate their knowledge. This has permitted improved links between 'the meat' and 'the thoughts'.

We can now, for example, see links between learning a new idea, (that is, holding it briefly) and remembering it several days later. Neuropsychological studies have shown that forming a new idea is matched by changed electrical activity in some synapses. Storing the idea in long term memory involves changing the structure of proteins and sugars in subcortical areas of the brain.

This means

learn new idea, retain briefly	Transfer to LTM hippocampus	store and retain ideas long term
change in electrical activity at the synapses of neuronal cells		change in proteins in brain and permanent synapse links in temporal area

This doesn't mean we should have children eat more sweets to build up their long term memory ability. A key issue for us, however, are the mental actions we have students take to make these changes. There are learning actions students can take to cause the sugar molecules to change, for example, What are the main ideas ? What are they like that I already know ? Where do they fit in ?"

These links have allowed us to understand exceptional thinking and behaviour. Recently we heard of a gifted mathematician who was able to produce superior outcomes was shown to be using at once areas of the brain that most people didn't use simultaneously. We need to examine the efficacy of some 'brain models' of learning, for example, 'right brain learning' or 'whole brain learning'.

The link between emotion and learning a particular set of ideas that we mentioned earlier is also shown in neuropsychology. The information defining the ideas passes through the areas of the brain that handle emotions on their pathway to the area of the cortex where they are processed.

Music can influence learning effectiveness. Learning while you listen to Mozart's music can assist students to learn. It is believed that this is because the rhythmic patterns in the music link with and induce particular brain waves that assist the storage of knowledge. One school in which I taught in the 1970s alternated between ballet and marching music in the 5 minute break between classes. I often had the feeling of pirouetting into some maths classes and goose-stepping into others.

Interest has recently been invested in how particular vitamins and minerals affect learning ability. We have known for a while that Ritalin can help some students temporarily to organise their brain hardware and focus attention while some food colourings and foods such as Twisties can lead to hyperactivity for some students. Over the last 7 years a number of studies have shown that memory difficulties such as recall of vocabulary, disorientation and problem solving ability are often linked with reduced beta carotene and vitamins B6 and B12. Reduced ability to concentrate, mood disorders, fatigue and irritability have been linked with lower niacin and thiamin. Foods like Vegemite are rich in some of these chemicals. Not only can we have 'happy little vegemites' but also 'clever little vegemites'. These studies show how learning ability should not be seen in isolation from the more 'hard ware' aspects.

Colour in information can also influence learning. We are all aware that particular colour combinations in art and film are effective in both assisting memory and emotions. Artists and film directors know about these effects intuitively. In teaching, using the same colour on a white board for a topic on a second occasion can help students recall what they learnt on the first occasion.

Learning in present day classrooms is to some extent 'hit and miss'. Many factors, both in the learner and the context, can reduce the efficiency with which learners change what they know. They may not, for example, 'pay attention' or disengage temporarily from the learning.

In the future, instead of electrical currents from our eyes and ears carrying the coded teaching information to the cortex, we may get the information cranially. In an English course of the future, for example, students may not get information about Macbeth by reading and listening. Instead, they may don 'knowledge inducers', rather like head phones or 'learning helmets' that radiate signals into particular parts of the brain. These in turn will stimulate the same electrical activity learners would have if they had operated very efficiently by reading, listening and writing.

We could even gaze further still into the future. Instead of improving my knowledge of physics by reading, listening and doing, I may be able to 'eat a Year 12 physics apple'. The genetically modified fruit would have chemicals that induce the brain to act in specific ways necessary for building on my physics knowledge. The chemicals could induce electrical activity that led to me being challenged to learn the new ideas, to stimulate what I already know, and that code the stimulus information sensations that I would otherwise get from a text. You can hear the dialogue "Take your physics at morning tea time' or "I want 2 kilo of Year 11 economics'.

In this case we would have gone 'full circle'. Some of will remember that learning began in the Garden of Eden when the snake suggested that Eve tempt Adam to bite the apple from the Tree of Knowledge.

In closing I would like to congratulate the Curriculum Corporation on the selection of its most timely and appropriate theme and thank the Corporation for including me in its work. Over the course of the conference we will be exposed to a plethora of stimulating ideas and distilled wisdom that will challenge our thinking on learning, pedagogy, curriculum and schooling. I would ask you to remember whenever you are reflecting on these issues that it all began with two leaf clad innocents, a an apple and a snake. All in paradise.

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