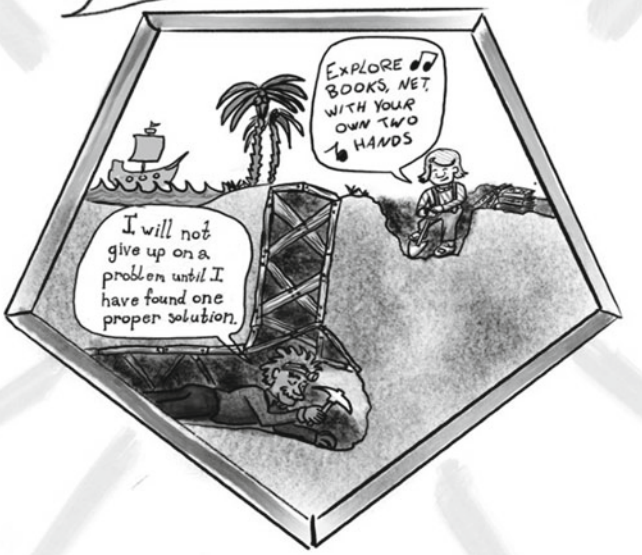
Chapter 2

What will we use?

Find & Generate



Chapter 2
What Will We Use?

2.1 Introducing the Models of Engaged Learning and Teaching

This chapter provides a deep and nuanced understanding of the Models of Engaged Learning and Teaching. Together, these models comprise much of what we may use across education to connect human brain development and education theory to diverse practice. Each of the models shares the six *facets* of sophisticated thinking that were foreshadowed in Chap. 1 through the analysis of *Parachute,* as well as the consideration of *learning autonomy* that is detailed below. The focus of Chap. 1 was on the role of education as a means of developing learners born from 2023 to 2030, who will be the problem-solvers, critical thinkers and researchers leading the planet from 2040. In order to achieve that purpose, the logic of Chap. 1 naturally led to the need for a conceptual framework that is broadly representative, across many perspectives, of learning and ideas about learning and teaching. Thus, Chapter 2 addresses this identified need by presenting the MELT as a viable option for a conceptualisation that we can use to span education and connect disparate parts.

In Sect. 2.2, this chapter presents an account from a university graduate who developed MELT skills at university and used these after graduation. Then Sects. 2.3.1–2.3.6 detail the six *facets* of MELT, including their affective domain, guiding questions and descriptions, and *learning autonomy*. Section 2.3.7 considers sophisticated learning as spiralling, recursive and messy and looks at the ethical and social dimensions of MELT. Section 2.4 in conclusion, is about engagement, adaptability, fluidity and ownership.

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2.1.1 A Holistic View

The MELT don't provide grounds for a proposal that education should develop new theorisations or characteristics. Rather, the aim is to consolidate the past 100 years of research and reflect human learning over the past 100,000 years in the MELT. Taken individually, each MELT *facet* and the consideration of *learning autonomy* is, in many respects, common, unsurprising and even too familiar. To reduce the effect of 'familiarity breeding contempt', the facets and learning autonomy are presented in a way that is intended to bring them to life, re-kindling a sense of their importance and demonstrating their synergistic power when taken as a whole. In order to achieve this, each *facet* and *learning autonomy* level is considered through the perspective of three educational contexts: primary schooling (*Place Value* from the preface), middle years of schooling (*Parachute* from Chap. 1) and a volunteering situation of a university graduate (*Silver Fluoride*, below). Through these multiple perspectives, the richness and complexity of each MELT *facet* and *learning autonomy* are partially revealed.

However, it is only possible to fully understand the MELT by perceiving the resonant energy of the set of *facets* and the continuum of *learning autonomy* together. This potential, this energy is more complex to convey. The stories give some idea of how the *facets* and *learning aut*onomy work together, functioning as indivisible parts of one precious jewel. Just as no facet of a jewel exists in isolation, all the *facets* of MELT work together to crystallise into something of shape and enduring beauty.

While the set of *facets* must be understood holistically, it can be helpful to delineate sophisticated thinking into separate facets. MELT takes what often remains implicit in education—the skills of sophisticated thinking—and makes them explicit. *Learning autonomy* intersects with the six *facets* of MELT in unpredictable, nonlinear ways. As noted in Chap. 1, the facets of MELT represent the 'what' of learning, while the *continuum of learner autonomy* represents the 'how', that is, the way in which the facets are operationalised by teachers and brought to life for students. In MELT, *learning autonomy* is considered to be a 'relationship' word, connecting learners to each other, to teachers and to the learning context.

This chapter pays more attention to the facet *embark & clarify* than to the other facets. This is because it is difficult to convey the sense of purpose epitomised by *embark & clarify*; students often find it hard to work out what their teachers want them to do, or to work out what they themselves will pursue. This difficulty is partly down to the fact that there are so many different ways to *embark & clarify* and the subject and discipline differences of how to begin often eclipse the similarities of complex starting processes. When learning something new, it is essential to begin correctly and to become increasingly clear about one's direction; the other five facets of the MELT depend absolutely on getting the purpose right. Except in the case of the simplest forms of learning, the embarking processes require clarification, often many times, over extended periods. It can be necessary to re-embark on a project time and again and re-clarify direction and purpose. The stories *Place Value* and *Parachute*, from primary schooling and secondary schooling, respectively, and the

Silver Fluoride account (from a university graduate, below) provide an understanding of the richness of the facet and the challenges it poses for engaged learning and teaching. A clear sense of how to *embark & clarify* frequently emerges out of the other five facets, with the end of one journey becoming the beginning of the next. A description of the familiar aspects that comprise the MELT follows.

2.1.2 The Origins of the MELT

The MELT began with a blank whiteboard and a question: what are we as teachers doing when we facilitate sophisticated student thinking? The resources that Kerry O'Regan and I used to answer this question were the literature and reflections on our teaching of well-scaffolded inquiry-based learning [2]. The *facets* of the MELT's were informed by the Australian and New Zealand Institute of Information Literacy (ANZIIL) standards [3], the Structure of Observed Learning Outcomes (SOLO) taxonomy [4] and Bloom's taxonomies [5, 6]. Bloom's taxonomies consist of two separate hierarchical frameworks with fundamentally different premises for the cognitive domain [5] and the affective domain [6]. The values, attitudes and emotions associated with the affective domain are embedded in each MELT *facet*. This means that the MELT comprise one framework with cognitive domain and affective domain integrated into the *facets*.

A crucial intentional structural feature of MELT is that it represents the affective domain but does not elaborate on it. Affective aspects are presented using single-word adjectives describing a learner, whereas cognitive aspects are described and elaborated much more richly. This is not because the cognitive aspects are more important than the affective aspects. Rather, it is because assessing affect is risky [7]: assessing something so important yet difficult to probe can be counterproductive. However, the affective aspects are pivotal for whether learning happens or not. For example, students are more likely to learn if they are willing to take risks, where, for example, a creative writing student who's encouraged to experiment is more likely to come up with an original metaphor.

The design intention for MELT was to enable a conceptualisation that ran from primary school to post-graduation [8]. Most educational continua represent an increase from lower ability to higher, from less sophisticated to more sophisticated thinking. Yet each student potentially engages in thinking that is sophisticated within the context of their current educational level. Rather than describing an incremental, linear type of improvement, Kerry and I perceived a need to describe a continuum that spiralled so that it could represent learning from ECE to Ph.D. level, flowing throughout the years of education. This is because any domain with a linear increase will struggle to remain pertinent across the whole educational trajectory, and is therefore not helpful for forging connections across education.

2.1.3 *Learning Autonomy*

The *continuum of learning autonomy* [8] in the MELT is a way of describing an educative scaffolding process that may spiral over terms, semesters and years of education and is identical in character to, and informed by, Vygotsky's zone of proximal development [9]. As noted in Chap. 1, for the MELT, learning autonomy involves the movement of students between lower and higher levels of control over their own learning; back and forth, like the tides [10]. Table 2.1 shows more detail than Chap. 1 for a version of MELT that is designed for teachers, where educator scope for autonomy is delineated into five levels.

Learning autonomy emerged in our early research as a decisive factor for helping educators to conceive of ways to facilitate the learning of the *facets*, and to understand the ways in which students were actually performing [8, 11]. Drawing on Dewey [12] and the science education literature, we used terminology like 'closed inquiry and 'open inquiry' [13] for the endpoints of the continuum. 'Scaffolded' was a mid-point between 'closed' and 'open', and this three-level framing still seemed to leave educational leaps in the continuum that were conceptually too far in practice for students. So two levels on either side of 'scaffolded' were added, giving five levels.

A student-oriented three-level version of *learning autonomy* and teacher 'proximity' was developed, comprising emulate, improvise and initiate as mentioned in Chap. 1, and shown in more detail in Table 2.2. Three levels are in keeping with levels of delineation that have been widely used to convey Vygotsky's ZPD from a teacher's perspective; model, scaffold and fade [14].

There is no clear border between the end of one level and the beginning of another. Interpretation of autonomy is dependent on a deep knowledge of context and students, and the *continuum of learning autonomy* is a tool for planning and analysing, not for measuring in ways that produce meaningful numbers (though we tried this approach initially) [15]. The overlap between educator-provided scope for *learning* autonomy and student *learning* autonomy as experienced by them is shown in Table 2.3.

Table 2.1 Teacher extent of scope for *learning autonomy*

Prescribed Highly structured directions and modelling from educator prompt learning, in which…	**Bounded** Boundaries set and limited directions from educator channel learning in which…	**Scaffolded** Scaffolds placed by educator shape independent learning, in which…	**Open-ended** Students initiate, with guidance from the educator.	**Unbounded** Students determine guidelines for learning that are in accord with subject, discipline or context.

Table 2.2 Three-level continuum of learner autonomy

Emulate	**Improvise**	**Initiate**
Follow your teacher's lead, so that you learn ways of doing things and about things.	Work creatively within your teacher's guidelines and *improve* or adapt what was given to you.	You drive the learning, deciding your purpose and how to achieve it.

Table 2.3 Overlap between teacher scope for learning autonomy and the continuum of learning autonomy

Scope for Learning Autonomy (provided by educators)

Prescribed	Bounded	Scaffolded	Open-ended	Unbounded
Emulate		Improvise	Initiate	

Continuum of Learning Autonomy (what students do)

For each facet, consideration can be made for the level of educator-planned learner autonomy, called the *scope for learning autonomy*, and the actual autonomy that students work with, called simply *learning autonomy*, shown together in Table 2.3. This delineation between teacher intention (scope) and actual student learning autonomy is important for three reasons:

1. It clarifies the difference between teaching intentions and the lived reality of students.
2. It provides insights into the process of differentiating the curriculum, so that each student is more able to engage in the learning that they are ready for.
3. It challenges our concepts of assessment, including what is assessed and why. This is because many assessments place a uniform demand on student *learning autonomy*, as a result of which some students are under-prepared and others are under-challenged.

MELT are able to connect ECE to Ph.D., across disciplinary and transdisciplinary contexts, because the *learning autonomy* question is always pertinent across formal education: 'how much structure and guidance do students need?

2.2 Silver Fluoride

The higher education perspective given below in *Silver Fluoride* is an account by Kevin, a graduate whose oral health degree was influenced by MELT. In an interview, Kevin reflects on his planning for a volunteer placement in rural Cambodia after graduation, and what happened when he went and enacted his plans with the people

in that country. The version of MELT that Kevin's degree used was the Research Skill Development (RSD) framework, and this influenced the terminology that Kevin uses to describe his sophisticated thinking. Kevin's account and the earlier stories *Place Value* and *Parachute* are then used together to bring the seven core characteristics of MELT to life across the years of learning.

Silver Fluoride

Before I left for Cambodia yes—because I actually took a silver fluoride which is a product that we didn't even actually come into contact with in the Bachelor of Oral Health here. When we went for a placement for Canberra there was a tutor there that was working with us and she used it [silver fluoride] because she trained I think in Darwin or somewhere out and she was working out in the sticks and so they had that as a prevention for decay and all that sort of stuff so they were using that product a lot, but we didn't come into contact with it because it stains teeth and there's all these things that they don't like aesthetically so that's why we weren't using it, but it's like an amazing product because I was really looking into that because I thought that might be really beneficial for Cambodia because they don't get care often and they're considered more rural so I was doing a lot of research with that and I ended up purchasing some and taking it over with me and I was using it when I was over there [16].

2.3 Student Experiences of MELT Facets and Autonomy

The stories *Place Value* and *Parachute,* along with Kevin's account in *Silver Fluoride*, are used next to provide a deep understanding of each of the MELT facet's verb couplets, affective adjective, key question, detail and then a consideration of the *extent of learning autonomy* for that *facet.*

2.3.1 Embark & Clarify

Process	*Affective dimension*	*Question*
Embark & clarify	*Curious*	*What is our purpose?*

Detail: Students respond to, or initiate their own, direction, and clarify it while considering ethical, cultural, social and team (ECST) issues.

To *embark* is to begin the journey, but how do students *clarify* what their purpose actually is? Do they know their starting point, where they are going and how they might get there? There are many different ways of commencing. This variety of starting points is not only due to the fact that different disciplines have different processes and terminologies, but also because sophisticated thinking is non-linear; it

jumps around and is hard to capture. Embarking processes often require other *facets* of MELT to be actuated before what is embarked on becomes fully clarified. For example, in disciplines that start with a research question, where did that research question come from? Who framed it, and how did that educator, student or team come to that phrasing? Formal research questions sometimes start as questions of speculation and wondering about possibilities, or some intellectual dissonance that makes one curious. Sometimes the questions emerge as a synthesis of the literature, through conversations, or by clarification through teaching, and these typically require all the facets of the MELT.

The intentionally general verb *embark* is the first facet listed here because it is a logical starting point. However, it is frequently not the first facet that students begin within their learning endeavours. Sometimes we stumble on an issue or idea, sometimes we are inspired by curiosity about a phenomenon or issue, and sometimes we immerse ourselves in a lot of reading around a topic. Formal research questions are typically a 're-embarking'. That is, they follow on from a research journey that has involved much reading and synthesising of literature, observation, piloting, hypothesising, discussing, reflecting and deciding about which of all possible questions is the best one to pursue. The same is true for the processes of defining problems when problem-solving, or clarifying what decisions need to be made in evidence-based decision-making: the process of formulating a point of embarkation and clarifying takes time. The point of departure is so complex that it commonly requires all six facets of MELT to clarify and re-embark.

For students, a sense of purpose is vital in the voyage of discovery that we call learning. However, a sense of purpose is difficult to nurture if learning is prescribed by teachers, because compulsion or coercion increases the risk of compliance, where the purpose is stated and injected rather than internalised by the learner themselves. On the other hand, when students choose the direction of their own learning, there are many complexities for them and their teachers to deal with if they are to become clear about their purpose.

The central question for *embark & clarify* is 'What is our purpose?' The verbs *embark & clarify* and the question are in the plural form because of the social dynamic in teaching and learning. However, 'What is my purpose?' is the question for a student to ask themselves if engaged in an individual project. For educators trying to launch students into sophisticated (but guided) learning, the question is 'How do I convey the purpose to students?' Like all other facets, the nature of this facet can sometimes be better understood through the key question. Even better, the combination of the process verbs, description, key question and affective domain descriptor together provide a well-rounded sense of the parameters of a particular facet. To understand the mentality behind MELT, it is essential to understand the characteristics of each facet, for each MELT facet must be set into its context, and adaptations are typically required. Nowhere is the need for adaptation truer than the word of *embark*, which is almost always too general to be of direct use with students.

Embark emerged from the first ANZIIL standard, 'Recognises the need for knowledge' [3], which is one of the dozens of ways of commencing complex thinking. 'Embark' includes asking, hypothesising, identifying problems or patient needs,

aims, goals or potential, immersion in a reading, story or context, and so on. It is an intentionally general verb, and its conceptual power lies in its inclusion of multiple ways of beginning. In particular, it embraces the numerous ways in which sophisticated thinking begins, as operationalised by those who know best; the teachers, academics, tutors, parents and students. *Embark* connotes a journey, a voyage of discovery where there may be many points of disembarking and re-embarking, as well as hidden or anticipated perils. *Clarify* suggests an ongoing process, where things may be initially muddy, which is OK as long as clarity comes over time: 'In a world deluged by irrelevant information, clarity is power' [17].

The facet *embark & clarify* also addresses one of the holes in Bloom's taxonomy: because Bloom's research strategy was to gather teachers' perspectives, the hierarchy has content knowledge as the foundational taxon, and so is suggestive of learning always commencing with content knowledge. This is frequently the case in education, but by no means is it or should it be always the case. As a hierarchical structure, Bloom's taxonomy locked in a mentality of content knowledge acquisition first, whereas MELT treats Bloom's verbs as fluid, non-sequential, but vital. Knowledge is always important in learning, but it is not always the starting point, especially in the context of connected learning that happens online.

The ethical, social and cultural considerations of engaged learning are the only elements mentioned in two facets, in *embark & clarify* and in *communicate & apply*. The six ANZIIL Standards, as the starting point for the six facets, articulated the ethical, social and cultural dimensions in the 'standard' concerned with communication. However, in 2012, a review of the facets by a variety of academics who had used MELT led to their strong demand that ethical, social and cultural dimensions also be represented not only in *communicate & apply*, but also *embark & clarify*. The academics perceived that the ethical, social and cultural dimensions were so crucial to engaged learning that they needed to be explicit first and last. The reasons for this come through clearly in *Silver Fluoride*, as Kevin engages with people living in villages in Cambodia through the use of an outmoded Oral Health treatment. Kevin's ethical decision is to prioritise dental health over aesthetics in that context, rightly or wrongly. There is always the need for teachers to consider the ethical, social and cultural dimensions first and last, and for students to learn to do so.

In terms of the social dimension, often people embark on sophisticated learning individually. However, MELT articulations tend to be in a plural form, for example, 'embark' rather than 'embarks', to emphasise the social aspects of learning. Education frequently entails social interaction, with the teacher and other students playing a major role in the learning environment even when students are working individually, as shown in *Parachute*. Determining purpose as an individual is difficult, and it is often even more complicated for teams to mutually develop a sense of direction that is clear to all involved.

The ethical and cultural elements of sophisticated thinking often do or should dictate direction, and need to be considered early in order to avoid conflict and unfair or adversarial processes or outcomes. The sorts of questions teachers or students ask, project goals they set or problems they identify all are best scrutinised from an ethical perspective, early on. For example, a project in mathematics that asks 'What

did the ancient Greeks contribute to trigonometry?' may steer students away from all the work that happened in the Middle East between the era of the last influential Greek mathematicians (around 2,200 years ago) [18] and the mathematical concepts' reception in Europe (about 900 years ago) [19]. The 1,300 years in between saw much translation, development and addition of concepts by scholars in the Middle East and India, so they ended up not just with the Greeks' trigonometry, but also the Arabic–Hindu number system (that is the same system used currently in the West, including in *Place Value)*, algebra and sophisticated trigonometry applications, all from the Middle East and India [19]. A culturally aware question, instead of the one above, would be "Who contributed to the development of trigonometry, and what were their contributions?" This leaves the question open, rather than eliminating entire cultures' contributions. Of course, the process could be scaffolded: "What did the ancient Greeks contribute to Trigonometry" could be asked first, then 'What did the Middle East contribute to Trigonometry?" Alternatively, different cultures could be allocated to teams who would be asked to report back to the whole class.

This example necessarily throws up ethical dimensions too: is it ethical to give no attribution of ideas to their developers? The wrong or incomplete attribution of ideas could be seen as unethical, a form of plagiarism. Therefore, it makes sense that ethical and cultural dimensions are located also in *communicate & apply*, where, for example, citation issues may be portrayed as ethical and cultural issues, rather than as a bureaucratic enterprise. So the ethical, cultural and social dimensions need to be part of the product or outcomes of sophisticated thinking, but especially integral to the learning processes of *communicating & applying* and *embarking & clarifying.*

In *Parachute*, Shelly decided to explore differences in parachute shapes, while Katie emulated the teacher's lead to explore differences in materials. Shelly in effect self-identified 'shape' as her independent variable, and to do so required high levels of cognitive ability. She also operationalised this independent variable using two shapes: square versus round parachute. Katie, following a process that had been modelled by the teacher, faced the difficult prospect of clarifying and understanding the teacher's intention in order to answer the question, 'what is my purpose?' Shelly embarked by posing a research question, and then she seemed to formulate a null hypothesis 'If the key factors are the same, the parachute should come down at the same rate'. However, in the simple structures of Year 8 science, students were asked merely for an aim. Whether embarkation entails developing an aim, a research question, a hypothesis, a null hypothesis or a combination of these, serious work is typically required to conceptualise and articulate a way of embarking.

For Kevin in *Silver Fluoride*, embarking involved clarifying the aims of his visit to Cambodia around the general idea of providing dental help to people who usually received none, all on a volunteer's budget. Embarking for him involved the process of getting to the question 'what would happen if I used silver fluoride?' This question was prompted by his memory of a placement experience from his degree where a tutor had mentioned silver fluoride use with people in remote contexts. As his bachelor's degree did not cover silver fluoride formally, Kevin needed to be open-minded in order to consider whether this compound could be relevant in the context of a developing nation. The ethical and social issues were paramount, as dentists in

developed nations have stopped using silver fluoride due to cosmetic concerns [20]. But Kevin inferred that rural Cambodians would prioritise keeping their teeth over concerns about stained teeth. Kevin could have been wrong, and this was an ethically, culturally and socially charged endeavour in which he took a calculated risk.

The children in *Place Value* were in play mode around the tree, and were driven by curiosity and mimicry of other children, engaging with the familiar and the unfamiliar. The children were having fun doing what they wanted; the curriculum was unknown to me as an observer, but the learning seemed to be substantial. The children were also driven by an impetus towards togetherness, and this togetherness did not restrict their individual exploration.

Some of those children were in the classroom the next day, and had to understand the complex ideas underlying the mathematical concept of 'place value'. However, it was difficult for them to read the term correctly, let alone anticipate or deduce the purpose of the activity. Nevertheless, the children were lively and enjoyed raising their voices in a chant with the teacher. It is not clear whether students were able to connect the original chant of 'place value' to the sequencing activity they engaged in. But we will see in later facets how complex the 'place value' concept is, and how the concept itself is a voyage of discovery requiring many points of embarking and re-embarking before it can be fully grasped.

Embark & clarify, the MELT verb-pair denoting commencement, has proven to be fit-for-purpose because it is necessarily broad. As such, it encapsulates the many starting and re-starting points required for engaged learning and teaching, from clarifying what a teacher wants, to determining what a patient needs, to selecting independent variables, to wondering what to play with under a tree. You will see in Chap. 3 that there are many ways educators and students have brought *embark & clarify* to life, and that teachers choose verbs that are appropriate, context-based ways of commencing. Example verbs that educators have used for 'embark' include the following:

- Ask,
- Question,
- Specify aim,
- Determine goal,
- Define problem,
- Define specifications,
- Diagnose need,
- Identify issue,
- Recognise,
- Speculate,
- Immerse,
- Probe.

Affective aspects

Embarking is complex and, like all the facets, involves an interaction between the cognitive and the affective. Shelly's willingness to break away from the teacher's example was full of risks. Was she driven by some curiosity—provoked by an interest

in shapes or a TV show on parachute design? Was she driven by the prospect of getting higher marks because she did not merely follow the teacher's example? Whatever drove her prompted a resilience, because throughout the difficult process, she kept going.

It is possible that the children playing in *Place Value* barely noticed their learning, and it's not likely that they consciously worked out what they were going to play. Rather, their decision-making was intuitive, spontaneous and curiosity driven. Open-slather learning can be bewildering, but somehow young children find it in themselves to play and learn in very unpredictable ways. In contrast, the children over seven playing nearby chose a fun activity (volleyball) with known and challenging parameters. There is a big difference between autonomous play and playing a game with pre-set rules. In terms of measured outcomes, students may learn more as a result of direct instruction than play, but that doesn't mean that the learning which comes from direct instruction is deeper, more comprehensive or more useful. It may merely be more measurable. While the ability of students to propose researchable questions is legitimately assessable, affective aspects of *embark & clarify*, like 'curiosity', are much more difficult to measure. This doesn't make curiosity less valuable or important; rather, it means that the complex and vital affective domain needs to be thoughtfully taken into consideration by educators in all learning design.

In *Place Value*, the maths learning was at the opposite end of the autonomy spectrum to the play around the tree, with a specified curriculum and predetermined answers. However, the teacher rarely corrected any child, instead gave cues like pauses in pointing at numbers, and silences. Then she continued, asking, 'is any number in the wrong place?' and gave students time to ponder. Perhaps most important, she structured in opportunities for student self-correction later in the sequence of events. She operated with tact, sensing that students needed feedback, but that feedback needed to be sensitive and non-accusatory in nature and, as much as possible, to come from other students. Terms like 'maths anxiety' spring to mind, especially if a child is struggling with more basic aspects of the lesson, like reading a number as 'fourteen' instead of 'forty-one'. For the teacher, the affective dimension of that lesson may have been something akin to 'soothing' or 'reconciling', rather than curiosity.

In terms of ethical, social and cultural aspects, the teacher used the powerful influence of spatial togetherness on the *italitali* mat and chanting of terminology to weave a sense of social cohesion and support. For students, to even pronounce the term 'place value' was challenging; initially, the students seemed to be confounded by another maths term, reading the flashcard as 'plus value'. Some of their earlier experiences with pairs of numbers placed side by side would doubtless have involved addition, which may have led to their confusion. So the knowledge base they needed to draw on was shifting, becoming more sophisticated and more abstract. The concept of 'place value' changes everything, and the students needed to work out what this teacher wanted them to do with this place that was supposed to be so valuable, but which maybe didn't seem as valuable as their tree place by the water. The question of what students 'value' influences every face-to-face class interaction, including for students who prefer and value online worlds.

The affective descriptor for *embark & clarify* needs to be responsive to context. For Kevin to begin to probe the merits of a medication which was not authorised in his degree, he was driven by empathy for the people of rural Cambodia. Kevin and eight other university students who completed the Bachelor of Oral Health were interviewed one year after completion. Analysis of the interviews showed that for them, *embark & clarify* was complex in the affective domain, initiated by numerous and diverse interactions, and seemed to be much more nuanced and context-sensitive than any other facet [21]. Sometimes, sophisticated thinking is driven by curiosity, sometimes by empathy for patient needs and sometimes by passion for an issue [16]. This starting point may be initiated by a teacher, as shown in the class context of *Place Value*, and in such cases, the challenge is to clarify what the teacher wants. In cases where the starting point is initiated by a student, the process of clarification can end up being even more complex, with students needing to fine-tune the question, aim or need. In addition to *curious*, the study in the Oral Health context found other affective descriptors that impelled graduates to *embark*: passion, ownership, interest in learning, implications of not researching, boredom and the need to justify [16]. Therefore research is showing that *embarking & clarifying* has, to date, the most complex cognitive and affective domains. An implication is that this facet requires more context-specific modelling by teachers than currently occurs, more practice in diverse contexts and more explicit connections between contexts. If that all were to occur, then the metacognition of students in relation to how they *embark* will be enhanced, and they will develop a sense of purpose for their own learning.

Einstein looked to the affective domain to explain his success as a learner: 'I am not especially gifted or talented. I am only very, very curious' [22]. Einstein's self-characterisation is one reason that 'curious' is used as a placeholder for affect in MELT. However, other affective descriptors are often more pertinent to the context and should be chosen carefully by educators or students and used instead. At times, identifying excess and deficit affect associated with each facet is useful, and for *embark & clarify* these are *obsessive* and *disengaged,* respectively.

Autonomy

Each facet may place its own demands on students, experience by learning experience, task by task, assessment by assessment, project by project, including how much autonomy is provided and how much each student operates with. The two stories and the graduate account are next compared and contrasted in terms of *learner autonomy* in order to elucidate this concept. The children playing under the tree embarked with a high level of autonomy, with no obvious supervision. They determined what they would play, where, with whom and for how long. But the next day in the maths class, three of those same children were grappling with the teacher's aim for the lesson. Their embarkation was highly prescribed and required sophisticated and abstract thinking. The students had an oral familiarity with numbers, but found it difficult to get the right-to-left orientation correct. It was daunting for them to understand what value a specific place or location gave a numeral compared to another numeral. The class embarked on learning content knowledge specified by the teacher and with which few students were familiar, and this required much clarification and re-clarification.

Kevin determined to explore the value of silver fluoride without boundaries set by others. The potential risks and benefits of the substance were his to weigh up, and his *innovative* approach may have led to some severe problems. His decision to act in such an autonomous way may have been driven by his empathy for the people, his curiosity about a now-abandoned medical approach, or any number of other affective factors.

Shelly took the opportunity to pose her own question, about parachute shape, *improvising* in a way that was in keeping with the *scaffolded* scope provided, with some teacher parameters and occasional guidance. Katie, in the same classroom, *emulated* the teacher's example and stuck to a prescribed question about parachute material.

Shelly's method of embarkation resulted in different ramifications to Katie's. Shelly's own choice of independent variable led to unanticipated problems, making engagement with the other MELT facets substantially more complex than it was for Katie. The surprising element in *Parachute* is that Shelly seemed so clear so quickly about her direction, and never wavered from it. Even though she experienced multiple problems and hold-ups as she *improvised* and *innovated*, she actually submitted her final report on time, along with others who *emulated* the teacher's modelling. For many students, regardless of educational level, this quick clarification would not have happened, and they would consequently have failed to submit a report of any substance. The pressures are often against a student to be too innovative, and sometimes the perceived or actual risk causes students to emulate instead.

The two school stories and the graduate's account show the diverse range of student autonomy that was evident for *embark & clarify*. A similarly diverse range of autonomy was also evident in the case of the other facets, as shown below. Table 2.4 summarises the highest level of autonomy that was observed for each facet as demonstrated by participants in the stories and account.

Table 2.4 The highest level of *learning autonomy* evident for each facet, story by story

Facet	Place Value		Parachute		Silver Fluoride
	Children around tree	Children in class	Shelly	Katie	Kevin
Embark & clarify	Initiate	Emulate	Improvises	Emulates	Initiates
Find & generate	Initiate	Emulate	Improvises	Emulates	Initiates
Evaluate & reflect	Initiate	Emulate	Initiates	Emulates	Initiates
Organise & manage	Initiate	Emulate	Initiates	Emulates	Initiates
Analyse & synthesise	Initiate	Improvise	Initiates	Emulates	Initiates
Communicate & apply	Initiate	Improvise	Improvises	Emulates	Initiates

Within the same learning context, different students work at differing points on the *continuum of learning autonomy*, regardless of teacher intention, and this is seen in *Parachute*. Some students frequently seek out clarification, ask what is next, request specified processes, and pursue a multitude of ways of working with the autonomy akin to *emulate*, regardless of whether the teacher provides a learning task that is engineered for students to *improvise* or *initiate*. In *Parachute,* Katie emulated the teacher's model for all six facets, while Shelly initiated *evaluating, organising* and *analysing* and improvised in the other three *facets*. Same classroom facilitation, with two very different student experiences. The same six-year-olds in *Place Value* were playing highly autonomously one day and learning with *prescribed* facilitation the next. This demonstrates that, in MELT, autonomy is not a characteristic that one acquires, but something which varies according to the relationship of a learner to teachers, other learners and the context.

2.3.2 Find & Generate

Process	***Affective dimension***	***Question***
Find & generate	*Determined*	*What will we use?*

Detail: Students *find* information and tools, and generate data/ideas using appropriate methodologies.

The MELT facet *find & generate* is concerned with using methods to make available elements that we will use, as dictated by a particular purpose. These 'elements' could be the information or data needed to address a research question—tables of results from published articles, for example, or data from one's own experiments. Elements could be physical or electronic tools, equipment or manuscripts. A chemist once said 'A couple of months in the chemistry lab can save you a couple of hours in the library' [23]. This facetious comment, written before the advent of the Internet, is a reminder that seeking already-existing information can prevent the unnecessary wastage of resources required to generate data. Seeking others' information or generating one's own data both require methodologies that are learned over time and that are context-specific.

Kevin the graduate was prompted by his impending visit to consider whether silver fluoride may be useful in Cambodian villages. With this purpose in mind, his self-determined need was to look up product and usage information, find out about side effects, and consider the costs, packing and customs requirements associated with taking silver fluoride overseas. When in Cambodia, he also had to *find* patients whose needs were well-suited to his treatment and not apply a one-size-fits-all strategy. Shelly's task looks more complex, as she needed to generate primary data and a protocol to achieve this, as well as coming to the realisation that she had to control the size of the parachute, and therefore use mathematical equations to calculate its optimal area.

The six-year-olds in *Place Value* had to *find* the 'place' that bestows value on numerals. For each two-digit number, the six-year-olds had to locate the numeral on the left and interpret it differently than if it was by itself. This was not at all straightforward, as evidenced when the students read 'forty-one' as 'fourteen', and the group of eight students inserted forty-one immediately after eleven in the sequence of numbers. Finding the right 'place' made all the difference in terms of determining the correct number sequence, and the task was initially beyond the understanding of almost the whole class. We wouldn't normally think of reading two-digit numbers as 'finding', but that may be because we forget how difficult the task is the first time around, when reading numbers of more than one digit requires locating the left-hand numeral in a two-digit number and assigning that number a special value. Locating the place of value was potentially bewildering for those who did not know their left hand from their right.

When three of the six-year-olds were playing around the tree the day before the maths lesson, they had many shells, seeds and other objects to *find*. Sometimes, the objects which they found prompted what they would do—a natural 'object-based' learning [24]. This type of learning was less about working out someone else's (cryptic) meaning about, for example, where 'place value is found'. The type of learning was more about a way of finding that gave way to more finding, as when a child found a specific shell and suddenly noticed specimens of the same shell all around them. The potential for finding was rich, with new things constantly being washed up, blown in or dropped down. As the seasons changed, so did the weather, the texture of the bark, and the character of nearby flowers and seeds. What was findable in and under the tree provided a rich learning environment that prompted the children to engage in multifaceted sophisticated thinking.

Affect

The place-holding affective adjective for *find & generate* is *determined*—a determined student pushing on to *find* relevant and useful information or to generate data. Shelly epitomises this, as even in an eighty-minute episode she was fierce in her determination to generate pertinent data despite the pressures of time, equipment and lack of support. Shelly showed determination to not generate just any data, but data that was trustworthy, as shown by her frequent writing, erasure and rewriting of measurements.

For the children in *Place Value*, the safety of the tree provided many opportunities to *find* and to *generate* ideas that they could further explore. There is a sense that the 'finding' in this setting was expansive, in contrast with the classroom where the finding process came across as almost pedantic. Under the tree, some children moved from one activity to another, and you might call that 'exploration'. But in a classroom context, that same way of learning could be called 'unfocussed'. How did the children navigate affectively between these two learning worlds on a daily basis? Did the classroom learning partially impel students, by the time they were seven-year-olds, to play games with other people's rules—like volleyball? Or is the progression from unbounded play to play with boundaries just a natural part of

childhood development? Where the affective domain for *find & generate* is taken to an extreme, it becomes *pedantic*; a deficit in this affect could be called *slapdash*.

Autonomy

The children in *Place Value* are again at opposite ends of the *learning autonomy* continuum when tree-based finding is compared with classroom-based finding. In the tree, what the children found was constrained only by what remained, what was grown and what had recently washed up, dropped down and blown in, and so the children improvised continuously in terms of *find & generate*. In the maths class, their finding was prescribed down to a precise location: the number on the left, which had a special value. In the classroom, there was no opportunity for the children to improvise on that convention, with the expectation by the teacher that they would emulate.

In *Parachute*, Katie emulated the teacher's protocol and generated data in keeping with prescribed learning autonomy. Shelly had some scaffolds set by the teacher, but also had a high degree of independence within those scaffolds, improvising the protocol to suit her questions and generating data as she went. Kevin innovated, with the freedom to determine which product information or application processes he needed to know about, including how he could get the silver fluoride safely overseas.

2.3.3 Evaluate & Reflect

Process	*Affective dimension*	*Question*
Evaluate & reflect	*Discerning*	*What do we trust?*

Detail: Students evaluate the credibility of sources, information, data and ideas, and through reflection make their own learning processes visible.

The process of finding information or generating data naturally leads to questions about the trustworthiness of that information or data. Should students believe others' information, including the teacher's, by default? A risk in the Information Age is that students may become gullible consumers of information, and so the educative process must include ways for students to learn to *evaluate*. Likewise, students should not by default trust their own ideas or data, but should *evaluate* these and reflect on the processes they use throughout their own learning, including self-reflection to determine their own potential biases.

In *Place Value*, after the children called out 'fourteen' in response to the written number 'forty-one', the teacher cued to students that there may be an error, by repeating the first part of the number: 'Four…'. A student then self-corrected with this prompting, calling the number 'fourteen'. When the class was prompted by the teacher to indicate whether the initial number sequence was correct, many students cried 'no', but no-one volunteered which number was incorrect until one girl standing

in the line of eight students pointed at 'forty-one'. The teacher asked where 'forty-one' should go. Many children pointed to the next position up, so the teacher prompted the child holding 'forty-one' and the child holding 'seventeen' to shuffle and change places.

It is one thing to know what is wrong, and another thing to make it right. The evaluation process was incremental—students caused 'forty-one' to move to the right-hand side of seventeen, but not past twenty or twenty-nine. It may have been initially that the student holding the 'forty-one' saw it as 'fourteen', and so he was correct in sequencing it between nine and seventeen. But with the realisation that it was not fourteen but forty-one, there was no aspect that was correct in the sequence '17, 41, 20'. The salient aspect for *evaluate* is that the teacher prioritised evaluative thinking by allowing the class to place forty-one incorrectly, knowing the continuation of the exercise allowed for further correction. In other words, the teacher's Socratic questioning focused on the process of evaluation, not on getting the correct answer. This approach can take some of the fear out of learning, if students can incrementally correct rather than being corrected first-off. The teacher could also have asked for reflection at the end of that task: 'What was one number that started in the wrong place and now is in the right place?' and 'What is more important—that we got it right the first time, or got it right in the end?' In that way, she would have been helping students learn to be evaluative and reflective.

Kevin had to decide whether the silver fluoride's negatives (such as staining of teeth) were outweighed by the positives of tooth decay prevention. With this in mind, his cost–benefit analysis for potential patients in Cambodia would be very different from a cost–benefit analysis for urban dwellers in a developed nation. This is because evaluation is context-sensitive, and in this case determined by cultural and social factors, as well as by medical and economic ones.

In *Parachute*, Shelly engaged in evaluative thinking, measuring, writing, erasing, re-measuring, rewriting and erasing numbers that represented her measured drop times. When Mrs Breen asked, 'Did you use several measurements?' she was getting at the underlying repeatability of measurements in science, not relying on a single measure. This is a kind of incremental approach towards a 'true' value, where random errors decrease as the number of measurements increases. Shelly answered 'yes' truthfully. And with her repeated rubbing-out of numbers, she indicated a dissatisfaction with some of her measurements—an evaluative decision in which she was being discerning. Perhaps this is because she realised a problem with the measurement, such as stopping her timer too early or starting too late, or that the parachute didn't fully open. If that was the case, she was engaging in an evaluative search for accurate measurements. It is also possible that she knew that measurements shouldn't be too spread out, which would indicate a lack of precision, and she wanted to eliminate some recorded numbers that made her experiment seem to lack quality. Given the rushed timeframe, whether she was evaluating the measures themselves, or the appearance of her experiment, she demonstrated a high level of evaluative thinking.

Nevertheless, it was Shelly's evaluative thinking in *Parachute* that shocked me. How could a series of maths calculations leave her to critique not the actual numbers she obtained, but the shortfall of materials ('there isn't enough')? In the complexities

of a genuinely open inquiry, where Shelly autonomously determined independent, dependent and key-controlled variables, she failed to make an absolutely vital evaluation of size. She seemed to believe that her hand-sized circle would be matched in the area by a square bigger than her desk. Ultimately, she applied a wrong maths formula—perimeter of a square instead of area of a square—but one would hope the discrepancy would have been enough for Shelly to stop and think that there must be a calculation error. This did not happen without intervention.

Affect: Discerning

Place Value's maths lesson required students to be discerning, requiring more than the evaluative element discussed earlier. Rather it was epitomised by the student who took a risk and pointed at the incorrect number—a willingness to question and maybe break through a group silence. Without this willingness, the teacher would have been left merely telling the group what was wrong, or the group would have been stuck with incorrect ideas.

Shelly was brave and smart in her parachute experiment. She was pressed for time because she chose to do what the teacher really wanted—her own investigation rather than what was modelled as an example. Everything had to be thought through, quickly, in eighty minutes minus the teacher's talk, making Shelly's task seriously complicated. In this case, she was asked to reflect on her learning: 'list what went wrong, and how you could improve', but Shelly had no time to work on that before she submitted her report. That was an opportunity missed, for her reflections on the eighty minutes may have taught her much. Shelly showed herself to be discerning, for example, by reporting only the positive aspects of her experiment when the teacher asked her how she was going, and through her willingness to erase and re-measure even under extreme time pressures. However, she did not see the size discrepancy resulting from her maths calculations for square size was a major concern.

Being discerning is vital for tree climbing; you have to avoid stepping onto a thin or dead branch that can't hold your weight, in effect asking each time 'is this branch strong enough?' with a compelling motivation to get this evaluative question right. The six-year-olds under the tree had no time pressure: if they were finding similar items, they could use any selection criteria for any feature they liked: species, colour, size, shape—there was no specific curriculum, and the exercise was self-correcting. Did they learn through outside play to be more evaluative or more reflective than in the classroom? For example, asking 'is this seed safe to eat?' is a very practical and natural question that fosters children to become discerning. Similarly, working without externally imposed boundaries, Kevin needed to be creatively discerning, projecting himself into an unfamiliar context, in effect asking himself before travelling 'will silver fluoride cause problems with and for villagers in Cambodia?'

Autonomy

Shelly sought for help, but only because she evaluated the plastic as too small to make a large-enough square. She self-evaluated many components of her work, especially the quality of data, by measuring, recording, erasing and re-measuring, and was mainly working at an *initiating* level of autonomy, even ignoring the teacher's

request for reflection on the process. The children in *Place Value* were probed with Socratic questioning by their teacher to structure their thinking at the bounded level, in order to enable their group evaluation. At times, one student's evaluation became a modelling for the others. The activity was more bounded than prescribed, because students had several options when choosing what number was in the wrong place, and then several options for where to move the numbers. Nevertheless, most students showed evidence of emulating the teacher or experienced peers in terms of evaluation, with only a few students improvising. Kevin's own evaluative standards (prevention of decay) and his decision to intentionally disregard certain criteria (aesthetics) all emerged from his innovation and sensitivity to the context.

2.3.4 Organise & Manage

Process	*Affective dimension*	*Question*
Organise & manage	*Harmonising*	*How do we arrange?*

Detail: Students *organise* information & data to reveal patterns/themes and *manage* teams and processes.

To *organise* information is to enable its effective use. Where there is a plethora of information and data, organisational processes and formats help to enable sophisticated thinking, especially analyses. Written, spoken and graphical conventions for organising information and data enable subject-appropriate ways of communicating. The management of resources (both physical and electronic), of people in teams and of time all strongly influence how sophisticated student thinking may become.

The children in and around the tree in *Place Value* played until after sunset, doing whatever they wanted in that timeframe. Learning wasn't pre-planned; it was managed by them—they organised their time, equipment, spatial arrangement and the things they found. They could be up the tree, under the tree, or indeed anywhere else, but perhaps something communal kept them within six metres of each other.

In the maths class, by stark contrast, there was strict management of the students: the bell would ring one hour after recess; the teacher determined the time allocated to whole-class tasks and then individual tasks; the space was teacher determined, whether on the Pacific Island *italitali* mat, standing in a line in front of the class or at individual desks. The tasks required pre-specified ways of organising the whole class and individual activities. Organisation and management, as dictated by the teacher, were directed towards achieving as much learning about place value as possible. But how often were the students aware of teacher modelling and their own use of managing and organising skills?

Shelly's experience was closer to that of the children when they played outside than their experience in the maths lesson. While she had about the same amount of time as the six-year-olds in the classroom, between the teacher explanations,

clarifications and requirements, she had to determine exactly how to manage herself and the experiment. For some aspects of organising the information, Shelly followed a standardised structure that she had used before: title, aim, results, with observation table and bar graph, and conclusion. However, for the table and graph, she had to *organise* the data by determining what the table comprised, identifying the x-axis and y-axis components of the graph, which required a degree of difficulty much higher than previous work, and all in a rushed timeframe.

Kevin had to work out the constraints of international travel and the village situation himself, and that these constraints would determine what he could carry and what he could manage to do. This included weight limits, knowing what goods could be imported to Cambodia, and the equipment available. Every aspect of *organise & manage* he determined and *initiated*.

Affect

Organise & manage can appear the least affective-oriented facet, but if students find the whole learning process under-stimulating, tedious or overly complex, then potential learning gains may not eventuate, no matter the learning design used. Einstein urged 'Out of clutter, find simplicity. From discord, find harmony' [25]. Organising cluttered information and managing discord requires an affective element: *harmonising*. This affective element addresses the question, 'how do we arrange?' How do we take cluttered, incoherent data or information and harmonise it in ways that enable effective analysis? How do we manage our team to work harmoniously? In *Place Value*, there are harmonious arrangements, with the children playing individually and yet socially in the shared tree-space. The highly prescribed maths lesson presents the harmonies of children on a pacific island mat chanting and learning together with the teacher. By calling out eight children to the front of the class, rather than individuals, the teacher managed the class harmoniously in the context of the cultural setting.

In *Parachute*, the time pressures brought discord to Shelly's open-ended experimentation, while Katie's prescribed experiment was relaxed. Even if Shelly learned more, what lesson did she walk away with? Given her level of anxiety, would her learning in this lesson have been less about experimental design and more about planning future work in which she could *emulate* the teacher's example, like other students?

Kevin was endeavouring to tread a fine line between the help that he hoped to give and the actual helpfulness of his planning, knowing that success would depend on how people in Cambodian villages actually reacted to stained teeth. That he used the silver fluoride a lot when he was over there suggests that he began by anticipating a high demand for the product, that he took a lot of it with him, and that this harmonised with the reality of what the Cambodians in villages were willing to do to protect their teeth.

Autonomy

Shelly struggled to squeeze her self-determined experiment into the 80 min allocated to the lesson. Her time management was paramount, and at one point she created for herself a resource management issue that didn't exist: she decided that she didn't

have enough material. She then spent time talking to me, trying to source more plastic. Simultaneously, she was organising data into tables and graphs that reflected her actual fields (time and shape) and measurements of time. Shelly *improvised* organisational structures because not all options were fully open. For example, she was provided with the structure of 'aim, method, results and conclusion', and was aware that her teacher would mark her work according to (unknown?) criteria after the class. But Shelly managed this experimental process amazingly well, to the extent that she did finish and submit, albeit without the self-reflective part that her teacher requested near the end of the vignette.

Manage & Organise were highly structured in the *Place Value* classroom, with student bodily emulation of the teacher's physical management. Innovation was epitomised by the students by the seashore and by Kevin.

2.3.5 Analyse & Synthesise

Process	*Affective dimension*	*Question*
Analyse & synthesise	*Creative*	*What does it mean?*

Details: Students *analyse* information/data critically and *synthesise* new knowledge to produce coherent individual/team understandings.

Analysis involves the complexities of breaking things down into their constituent parts and bringing them back together in a way that enables trends (in quantitative work) and themes (in qualitative work) to become evident. There is, then, a strong, recursive interaction between *organise* and *analyse*, through determining how information and data may be arranged to enable insight into what words, numbers, icons and other representations mean. Synthesis is the process of creating something new from all the constituent parts. At the most fundamental level, this entails an individual's construction of understanding, or a team's construction of understanding. Understanding may be manifest in all sorts of physical and digital representations, from essays to multimedia mash-ups. While 'understanding' is the second-from-bottom taxon in Bloom's Taxonomy of the Cognitive Domain, in MELT it emerges non-sequentially, and in some ways is a culmination of sophisticated learning.

When students *analyse & synthesise* others' information along with their own prior knowledge, they construct understanding new to themselves in a process that often involves creativity, or the creation of something new. Synthesis happens in the context of students' prior knowledge. In *Place Value*, the lesson focus is on the value associated with the 'place' of a numeral in a two-digit number. Single-digit numbers are relatively concrete, but a number represented by two or more numerals is a substantial abstraction. Without an understanding of the value attributed to a specific place (e.g. that the left-hand number in a two-digit numeral indicates the number of groups of ten, and the right-hand number indicates the number of units), students can make few conceptual advances in our decimal system of mathematics.

So, from the start of this activity in *Place Value*, there may have been some maths anxiety, especially given that English was the second language for all the students, so that their familiarity with number names would have been lower than if English was their mother tongue.

Whilst we saw in Sect. 2.3.3 that the six-year-olds evaluated 'forty-one' as being in the wrong place, this didn't automatically entail that they could locate the *right* place for the number. The students seemed to have trouble seeing the trend in numbers as a whole and being able to place forty-one correctly after twenty-nine—in other words, they struggled to *analyse*.

The teacher asked a question that seemed practical, but which actually required analytical thinking. It was not a question which merely evaluated whether forty-one was in an incorrect position; it also asked students to project the number to its proper place: 'So this forty-one should go *where*?' For students to see the numerical trend, to show analytical thinking, they needed to move forty-one up three places in the line. However, the students indicated that it should go past seventeen only, and the boy with forty-one moved up one place: '5, 9, 11, 17, **41**, 20, 29, 57'.

If the process of evaluating forty-one's position continued incrementally 'it's wrong here…. It's wrong here, ah, it's correct here', then it would have been a trial and error process. This would be similar to (but more sophisticated than) the evaluative thinking required to check whether a square peg fit into a round hole, and then trying each subsequent hole until it fits. The teacher knew that forty-one was still in the wrong place, but demonstrated pedagogical awareness that if she kept on asking 'are you sure?' regarding forty-one specifically, she would be cuing that forty-one *was* wrongly placed. Such a strategy may not even facilitate evaluative thinking; it would merely train students to read the teacher's cues.

The teacher instead asked, 'Any *other* number is in the wrong place?' Here, she shifted the class focus from forty-one, towards looking at all the numbers afresh and analysing the trend. One student evaluated 'twenty-nine' as being in the wrong place. The teacher then asked a question about twenty-nine, the same question she asked about forty-one. Again, in this context, this could have represented an attempt to elicit analytical thinking: 'Twenty-nine should go where?'

'Besides seventeen' one student called out—and the student with twenty-nine shuffled left, passing forty-one and twenty '5, 9, 11, 17, **29**, **41**, 20, 57.

Indeed, this was the first time a student required a number to move two places at once, and downstream at that. This one student had seen something in the trend (e.g., his internal reasoning may have been something like 'twenty-nine is lower than forty-one and higher than seventeen, so it should go between these two numbers'). This process of seeing the trend rather than engaging in evaluative trial and error indicates analytical reasoning. The sequence as yet was not perfected, but the student's request represented a major leap forward, from an incremental, evaluative process to a more analytical one. The other students could see and hear this, and realised that they too could do more than say 'not here'—instead, they could project a number into its correct location in the sequence. That leap of two places was a leap of insight for the child, and may have triggered some new ways of thinking for other children.

Still, it is hard to see errors, let alone trends in numbers, and when the teacher asked if there was any other number in the wrong place, the students called out together, 'No'. It may seem bewildering that thirty-one bright students 'missed' the '20', especially after another number in the twenties (twenty-nine) was just moved.

> 'Are you sure?' she presses.
> 'Twenty!' a boy calls out
> 'Right.' Where should it go?
> 'Besides seventeen'

Again, this child's analysis went beyond seeing that twenty was in the wrong position, into spotting the trend and placing the number in its correct place.

The students' process suggested that some of the students could *evaluate*, on a case-by-case basis, whether a number was in the right or the wrong position. But to *analyse* entailed being able to move a number to its correct position, even if this required big jumps. At the end of the activity, there were now two students who showed evidence of being analytical, and they modelled this ability to the class.

In *Parachute*, Shelly worked out that there was a difference in parachute drop times, and since she had controlled other factors, she inferred that the difference was due to the parachute's shape. She stated to Mrs Breen that 'the round one takes longer to hit the ground.' To reach this analysis, Shelly shifted from one particular observation ('the round parachute in each drop took longer') to a generalisation ('the round one [always] takes longer'). For her conclusion, she elaborated on that analysis to form a full synthesis of her previous and current understanding of the nature of science experiments, and of the analysis she conducted, to say, 'If the key factors are the same the parachute should come down at the same rate'. Because square versus round parachutes didn't have the same drop time, she synthesised her conclusion as a generalisation: 'the shape does matter to the time'. The finding that drop time depended on parachute shape represented a substantial synthesis of empirically based understanding, developed in an eighty-minute lesson by a thirteen-year-old student.

Kevin's analysis included a conscious consideration of social, cultural and contextual issues, in order to determine whether he was right in thinking that silver fluoride may have been appropriate. There was also a technical side to his analysis—e.g., 'how poisonous is silver fluoride if ingested, or if it makes contact with skin?' His analysis may not have stretched to 'how sustainable will this approach be for each village?' His final synthesis included the decision to take the compound, as well as considerations on how much to take, and how he would store it while travelling and when in the villages.

Affect: Creative

The *Place Value* maths activity was social, but frequently depended on an individual to go against the consensus and call out an error. This may have meant that some students who either saw a wrongly placed number, or who even saw where that number should go may have been inhibited to say so, perhaps because of cultural norms. The analytical learning evident in this activity seemed to rely on brave or confident individuals. To understand deeply what 'place value' meant, students had

to be intuitive; students who were cognitively and affectively engaged in the task had to be very creative to move from their original understanding to a newly constructed understanding of the concept. This creativity was evidenced in the leap of imagination required for one student to send one number multiple places downstream. Three students from the class showed the creativity to conjure up different games from scratch each day as they played by the seashore. Shelly's analysis followed a scientific protocol, but she creatively adapted it to her parachute experiment. Kevin showed the creativity needed to think outside the content box of his study program. This allowed him to consider, from a raft of potential contributions, what he could add to oral health practice in a rural context.

Autonomy

In the *Place Value* maths lesson, the students' analysis and synthesis were scaffolded by the teacher, who put structures in place to help students *analyse* the numerical trend and rearrange the numbers into their correct order. For some or most students, this was too big a step. In the process, there was no modelling from the teacher. But the teacher scaffolded the task so that students modelled to other students the process of analytical thinking. Such peer-to-peer modelling was envisaged by Vygotsky in the ZPD, and peer teaching is often regarded as more conducive to student learning than teacher talk [26].

Kevin's *initiation* of analysis was unbounded by any supervisory presence, but this unboundedness didn't mean 'anything goes'. This was especially true in terms of his patients' health, which was in his silver fluoride-laden hands. If Kevin, for example, ignored or overlooked a health warning, he may have endangered his patients. If applied inexpertly, the treatment may have been ineffective or counterproductive. Even though Kevin may have been working outside the boundaries of a specific health system, his status as a professional required him to be aware of how 'unbounded' his work was, and therefore to redouble caution, checking and rechecking dosages.

Shelly *initiated* her own *analysis & synthesis* and this was in keeping with the teacher's more open-ended intention, and so the teacher had no preconceived answer for Shelly's self-generated question. The teacher could check the process and the steps which Shelly used to get to her conclusion, but could not rightly correct the findings themselves.

2.3.6 Communicate & Apply

Process	*Affective dimension*	*Question*
Communicate & apply	*Constructive*	*How do we relate?*

Detail: Students *apply* their understanding and *discuss, listen, write, perform, respond to feedback* and *present* processes, knowledge and implications while heeding *ethical, cultural, social and team* (ECST) issues and audience needs.

Communication frequently is thought of in terms of written, spoken, multimedia and performance *products* for an audience, and application is thought to concern built solutions to a problem. However, like all the facets, *communicate* and *apply* are primarily *processes* that students engage in during sophisticated thinking, even though they may also comprise final outputs. Students begin by applying their prior knowledge to a task, and as they develop understanding, they apply that new understanding to their task. The communication process has many aspects, and involves more than speaking and writing—it also entails listening, reading, performing and responding to feedback. In the process of applying this facet, ethical, cultural, social and team (ECST) elements need to be emphasised, as mentioned for *embark & clarify*.

Whilst they seemed to be involved in individual agendas when I watched them playing around the tree, the children in *Place Value* were vocalising the whole time. Whether they were chatting, gibbering or explicitly communicating with each other, I couldn't tell. Although they were each doing different things, the proximity of the six children to each other was striking; they were together in individual ways. The three- to six-year-olds acted out the facet 'apply' through the use of their existing knowledge and turning their thoughts to their environment—was there something there which they didn't know about, or suddenly thought differently about? Would they apply their maths to counting objects? Would they arrange things on the mat in ways they had seen others do in a shop setting? Or would they just bounce in a branch, and somehow learn about natural rhythms, about the properties of living wood, of the texture of bark, and develop tacit knowledge of how to grip a moving branch?

In the village, many coconuts were harvested when green, a long time before they fell naturally, and so the village relied on good climbers. The boys in the village told me they could not climb a coconut tree until they were older than twelve—it required skill with a machete and upper body strength. But did climbing in the tree by the water provide a raft of knowledge and skills that could be applied later to climbing coconut trees?

The next day in the maths class, the teacher's use of a Pacific Island mat, the *italitali*, culturally affirmed the children's place in the Pacific. The communication between students was initially communal, with students chanting together and periodically falling into shared silence. When the eight students were allocated their numbers, they read them, and used the information of the two single-digit and six double-digit numbers to order themselves into a sequence. They used a lot of whispering and pointing, pushing and shuffling to end up with a communication product—their sequence of numbers—reached by consensus, under time pressure and maybe stage-fright. Standing there in their sequence, they hoped to *communicate* visually, holding numbers so that they were visible to the twenty-three others who remained on the *italitali* mat. Therefore, the group was exposed to critique because their communication was in plain sight and open to a form of peer-review. That the sequence was constructed by a group of students reduced potential feelings of exposure when compared, say, to an individual sequencing numbers on a whiteboard. Nevertheless, the eight students and their thinking were exposed. Students on the mat scanned the sequence time and again, and endeavoured

to *communicate* through silence, speaking or pointing their answer in response to the teacher's communication prompt, 'is there any number in the wrong place?' This evaluative question prompted students to answer with something specific, in contrast to a vaguer question, such as 'is this sequence correct?'

Maybe it's to be expected that the student who first communicated an answer to this question was engaged in the process of forming the sequence, rather than sitting passively on the mat. When number five pointed to forty-one, she broke the stillness which had suggested collective acquiescence regarding the correctness of the existing sequence. The student holding 'five' did not just *evaluate* the sequence and diagnose that it was wrong, but actively indicated through pointing and speaking which number in the sequence was incorrect. Once challenged, the class began to agree with her, and in that way, her communication broke a silence. Once the silence was broken, individual students worked up the courage to start challenging class consensus, and this moved the community forward towards the correct sequence. Once forty-one was challenged, students had to apply their knowledge to suggest *where* forty-one should go. After this, many students communicated by pointing, as if vocalising a specific place was too difficult or risky. The standing, pointing and shuffling made embodied communication the number one communication mode in the class. It was this form of communication that enabled some students to apply their knowledge of two-digit numbers.

In *Parachute*, Shelly wrote in her report,

> If the key factors are the same the parachute should come down at the same rate as it was not proven here I have come to the conclusion that the shape does matter to the time.

This excerpt is cryptic at first glance. But it closely follows the 'null hypothesis' strategy used commonly in science, whereby scientists try to show that there is no statistical difference, after which the discovery of a difference indicates that there must be a genuine difference in effect due to the independent variable. Shelly merely took averages, which are very weak descriptive statistics. Nevertheless, she adopted the persuasive grammatical structures of science to *communicate* in writing. However, she had made a similar point earlier when talking to Mrs Breen, in a way that was much easier to understand: 'the round one takes longer to hit the ground.' The report is much more science-speak than her oral communication, and as her main communication product, the report goes beyond communicating results and demonstrates her findings using scientific discourse. In choosing a communication style that was appropriate to the situation, Shelly did something that is vital in all learning contexts. The fact that different styles and modes are required in different settings suggests that 'communication' is not a singular skill. Rather, it comes in multiple forms, each of which must be learned and incorporated into a personal repository of styles to be drawn-upon as context demands.

When Kevin communicated with Cambodians in the village, he wanted them to have confidence that what he was offering would work. But his audience may not have wanted or understood a scientific discourse. In this situation, *apply* may have seemed more important to Kevin than *communicate*: 'I thought that might be really beneficial for Cambodia because they don't get care often.' He wanted and found

something that worked, and was driven to be constructive, to build up. He anticipated linguistic barriers, but knew that the care he could give would speak volumes.

For Kevin, communication included a willingness to listen to someone with an experience that differed from his, someone with rural experience, and this included practice that was contrary to standard practice in his degree. He used the silver fluoride 'a lot over there', implying that he persuaded people in the village to tolerate stained teeth in order to keep their teeth longer. Clearly, his intention was to be constructive. This is where the ethical, cultural and social dimensions really kick in. He applied the idea of silver fluoride, evaluated his use of it with people and decided to continue to use it a lot. Communication and application were a type of endpoint for his sophisticated thinking. But they are also a part of the process from the beginning, including listening, finding out what was currently available and what was applicable.

Affect: Constructive

The default affective adjective in MELT for this facet is *constructive*, used in the colloquial sense of 'you're a constructive person' or 'that's a constructive comment'. A constructive student or graduate desires to build up rather than self-promote in their applications and communications. Shelly endeavoured to not only be intrepid, but to craft a quality finding.

Kevin was a constructive graduate who volunteered, prepared and purchased equipment using his own money, well in advance. He communicated and maybe persuaded as he went, and applied his knowledge with the intention to add value to the lives of people who were otherwise unreached by dental services. In doing so, he personified the end-game of research and problem-solving: 'go to where the silence is and say something' [27]. Of course, it may be that having committed to silver fluoride, Kevin was doggedly committed to use it or get rid of it. There is the possibility that he foisted the product on a more vulnerable population, over-riding their aesthetic concerns. Kevin, and each of us, ethically and culturally must prioritise others and not use coercion to peddle wares or to enforce our own values, like a mini-colonisation.

The children in *Place Value* were preoccupied with play in the tree, and in that setting they entertained themselves without needing any adult resources. The eight children in line applied their understanding of place value and communicated this to the whole class. Their willingness to do this and to be critiqued enabled an entire constructive dialogue to be engineered by the teacher.

Autonomy

That communicative line-up in *Place Value* had predetermined boundaries, and even with one ultimate correct answer, the scope was there for incremental improvement. Giving the children some room to move enabled substantial learning. Kevin and the children under the tree had unbounded autonomy to *communicate* and *apply*. Shelly faced a mixed bag, with the prescribed structure of a lab write-up and her own innovations to report, whereas Katie stayed within the modelling provided, successfully *emulating* the teachers' lead.

2.3.7 *Spiralling, Recursive and Messy*

Sections 2.3.1–2.3.6 are arranged in a logical and coherent order and present as a more linear representation of the MELT facets. However, the reality of sophisticated learning is that it is messier than a sequence. At times, several facets occur simultaneously, or facets like *evaluate* and *reflect* are tightly coupled to every other facet. Simultaneously, purpose drives everything, frequently requiring a return to *embark & clarify*. It is to capture the non-sequential nature of sophisticated learning that MELT uses the word *facet:* It's as if there are six faces of one precious learning jewel, where different facets are emphasised depending on which way one holds the jewel, yet all co-exist simultaneously.

There are different practical ways that facets may interconnect or be emphasised in MELT. The ethical, cultural, social and team considerations are evident in *embark & clarify* and in *communicate & apply*, and as noted earlier this is the only repeated element in the explicit articulations of MELT. This double-mention was seen to be an essential emphasis that needed to be articulated explicitly in those *facets* often seen at the beginning and end of engaged learning. However, when students think in ways that are sophisticated for them, all *facets* are enacted continuously throughout the whole process. Most noticeably this occurs with *evaluate*, where questions, information, management and communication are always evaluated, or should be, and at times analysis is inseparable from evaluative process. The pentagon formulation of MELT also urges 'when in doubt, return to the centre' to *embark & clarify* 'what is our purpose?' This acknowledges the recursive, messy aspects of sophisticated thinking and the strong need for learner clarity, or more precisely, for learners to develop clarity of purpose. However, Chap. 3 provides examples where educators use the pentagon configuration and place one of the other five MELT facets in the centre, and this matches their emphasis for sophisticated thinking.

The cognitive and affective are not separated in MELT in the way that they were in Bloom's taxonomies. Separating these two sides of the same *facet* can provide a licence to prioritise one over the other. However, a challenge of modern education is to 'cover' the essential knowledge and skills for contemporary life, but in a way that provides at least enough motivation for students to acquire these, a challenge that requires simultaneous cognitive and affective considerations. I suggest that the above sections unpack some of the complexities of the processes in each story and account, and as educators, one of our challenges is to understand the complexity for students of affectively engaging in sophisticated learning. In all of the research on MELT implementation to date, student need and employ all six facets in activities that require anything more than dialogic-reporductive learning, and that such learning is always multifaceted needs further research. If the facets of MELT are not explicitly facilitated, at appropriate times, then the risk is under-developed student thinking being applied across the years of education. Therefore, another challenge is to facilitate the development of all of the facets that students need, in consideration of context, content knowledge and diversity of learners.

In Sect. 2.2, the more cognitive descriptions of MELT were co-presented with the un-elaborated affective domain, for these dimensions of learning mutually reinforce and co-exist. When designing any learning tasks (including assessment), educators need to consider affect, so that motivational elements in learning tasks are integral to curriculum and lesson design. But this does not mean the affective domain needs to be assessed, and the MELT's single-word affect descriptors are a type of warning: don't treat the affective domain in the same way as the cognitive domain. The affective domain is crucial because it is salient to ethical, cultural and social considerations for engaged teaching and learning.

As with all MELT terminology, the affective adjectives are context-sensitive, and should readily be adapted by educators to fit that context. For example, *curious* may be, at times, a word that is contrary to ethical and moral imperatives, and a word like *empathetic* may be more appropriate in the context of solving people's problems or dealing with patients. Kevin may have been curious to see if silver fluoride was effective, but hopefully his primary driver was empathy for people who had minimal access to dental care. In applying the affective descriptor for *communicate & apply—constructive*—it is important to pay heed to ethical and cultural issues. Some people may feel that 'constructive' contains overtones of colonisation, echoing Rome's mission to 'civilise' the world. In being *constructive*, one should avoid foisting one's own solutions or morals onto others; the ECST considerations are designed to check such impulses. If Kevin's silver fluoride solution proved to be socially or culturally inappropriate when he was in a village, he would need to heed this rather than persuading people with a medicine-only orientation, while defending himself as being *constructive*.

2.4 Conclusion: Engagement, Adaptability, Fluidity and Ownership

My operational definition of engagement is 'frequently socially interactive and always minds-on', and the six facets of MELT require engaged learners and engaged teachers. The shared conceptualisation afforded by MELT can broaden the community of people who are involved in using and discussing the models, making conversations richer: Librarians, casual staff, principals, museum directors, office staff, assistant lecturers, professors, parents and caregivers can be enjoined in conversations with teachers and students, whatever the years and focus of study.

However, a shared conceptualisation does not necessitate shared terminology, and adaptations to MELT are in the spirit of the models' broad parameters. Adaptation from a general description to context-sensitive applications is vital. At times, one context, such as a school or a university program, may require several different MELT that express core ideas in different ways. The challenge, then, is to help students realise that there is just one shared model at work, to help them make the connections between the different models, and to see how to generalise their

own learning as a whole. All of this is part of building and internalising their own personal models of learning, which will become a thinking routine that can guide them across their education.

Chapter 3 contains diverse examples of the explicit use of MELT. These examples demonstrate how different groups have taken the ideas presented here, adapted them and used them to help students understand what is going on in their learning. This level of fluidity is liberating and demanding. As MELT is not a generic model that guarantees effective learning through an off-the-shelf solution, but rather requires significant input to reformulate and re-articulate, it places demands on teachers. This is why the examples in Chap. 3 are so helpful: there is no need to re-invent the wheel if you can find and adapt from contexts close to yours. Educators making choices on how to adapt MELT to fit specific contexts and what to emphasise have a liberty that defers to their professional judgement. However, they cannot ignore that we all need to be better informed about how to enable sophisticated, multifaceted thinking.

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