
Addressing Diversity in an Early Years Mathematics Unit: a matter of design

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ABSTRACT In this article the manifold aims and theorised benefits of Learning by Design are explored and evaluated through the practices and experiences of an early years mathematics teacher. The article examines and elaborates the ways in which this teacher took up and embraced Learning by Design as both a professional meta-language and as a design scaffold that underpinned her classroom practices. In particular it is shown how Learning by Design equipped this teacher to design learning that was engaging, effective and inclusive of the diverse needs of her learners, and how she employed the language of Learning by Design to think-through, explain and articulate her work, thereby making her practices and experiences accessible to others. The research underpinning this article was drawn from a three-year project funded by the Australian Research Council.

A concern with diversity and difference is a hallmark of both Learning by Design (Kalantzis & Cope et al, 2005) and its forebear, multiliteracies theory (Cope & Kalantzis, 2000). Each theory begins from the premise that learners are fundamentally different, one from another, and that effective teaching and learning should acknowledge and work with these differences. Beginning from the position of learner difference means that teachers need to be skilled in using a variety of techniques, tools and modes of communication as well as the know-how to apply these tools and techniques using a range of pedagogies.

The theory of Learning by Design offers teachers both a pedagogical typology and a design framework – a sense-making structure for thinking through and organising a multiplicity of means, without which a teacher's practice could easily become a grab bag of well-intentioned but disconnected activities. However, the use of a variety of techniques, while necessary to accommodate and engage student differences, may not be sufficient for deep learning. The theory of Learning by Design suggests the impetus for deep learning lies in teachers carefully choosing, orchestrating and sequencing activities into a coherent pedagogical design.

Learning by Design provides teachers with a professional metalanguage with which to name their practices; a heuristic with which to identify gaps or habits in their ways of working; a framework for both designing learning and guiding practice; and a lens for analysing, explaining and discussing their designs and practices with colleagues. Learning by Design is also a broadly inclusive typology of teaching practices and pedagogies, a set of organising ideas, and a way of seeing, naming and reflecting on both designs and practices. Teachers who use this typology learn to see and respond to difference with and through the lens of Learning by Design.

The theory also acts as a kind of professional provocation – it suggests that it is possible to design learning that is inclusive of diverse students' needs and interests, learning which promotes belonging and learner transformation. The theory of Learning by Design contends that the path to inclusion, belonging and transformation is a product of thoughtful, premeditated design.

In this article, the above ideas are explored and elaborated via the practices of an early years mathematics teacher. This case study is drawn from research undertaken for a three-year research

project involving 50 teachers in 10 schools: Learning by Design: creating pedagogical frameworks for knowledge building in the 21st century (Australian Research Council [ARC], 2005-08).

Background to the Case Study

The ARC-funded Learning by Design project was an attempt to both understand and positively influence teachers' pedagogical practices. The teachers in this project were asked to 'test' the efficacy of Learning by Design by translating its theory of teaching and learning, via its pedagogical design framework, into both designs and practices. The theory of Learning by Design positions the teacher as a thoughtful, purposeful and deliberate designer of learning.

In order to test the efficacy of Learning by Design, teachers needed to learn the conceptual language which underpins the theory, its multilayered meanings and significances, as well as how to use this conceptual language to think about, organise and guide their planning and teaching practices. Teachers also needed to learn how to use the pedagogical framework to set out and document their designs. Moreover, they needed to develop a deep and sophisticated understanding of the concepts, language and theory, as well as the skills to translate them into learning experiences suited to their specific students and contexts. Without such depth of understanding, or the capacity to translate the theory into practice, there would be little prospect of significant impacts.

As researchers, we were looking for evidence as to whether and how using and applying the theory of Learning by Design (and the associated pedagogical framework) impacted teachers and learners while simultaneously facilitating, guiding and developing their understanding and application of this theory. This meant that the researchers were immersed in the theory and practice of Learning by Design for an extended period. While these direct experiences have contributed to this author's understanding of the theory and application of Learning by Design, they may also have limited his capacity to properly recognise its weaknesses and flaws. This possibility should be kept in mind as the reader engages with this article.

Teacher A, whose work is the focus of this case study, is a mature-aged teacher. She was one of the teachers in this three-year project. In this article, Teacher A's work and reflections on teaching mathematics to 'a very diverse class of 20 children', aged seven to eight years old and from low socio-economic backgrounds, is described and analysed in some detail. Teacher A used the Learning by Design pedagogical design framework to think through and design her mathematics unit. She also deliberately set out to investigate whether or not Learning by Design was making a positive difference to her teaching and to the outcomes achieved by the children in her charge. Teacher A chose four children with different abilities to track and document in terms of evaluating the effects of her use of the Learning by Design pedagogies and framework. Tracking and observing these four very different children provided Teacher A with an opportunity to deeply consider the effects of her practice on her students and the role played by Learning by Design in scaffolding this practice.

In this case study, the data has been drawn from Teacher A's perceptions of the impact and effects of Learning by Design on her practice and on students. This data was collected via multiple methods including: four multimodal research probes which Teacher A completed in 2006; a learning journal she maintained during 2007; video recordings of eight research workshops she attended in 2006 and 2007; interviews with her – one at the end of 2007 and another in mid 2008; and video data from the classroom captured by Teacher A and subsequently presented at the 2007 E-Learning Symposium at RMIT University. Teacher A's presentation at this symposium was also filmed and constitutes a further source of data. A final and important source of data was Teacher A's design for the unit of work titled 'Understanding Simple Unit and Group Fractions', which is at the heart of this study and at the heart of her symposium presentation.

The unit of work was designed inside the Learning by Design pedagogical framework, where such designs are called 'Learning Elements'. Teacher A's Learning Element has been systematically analysed in relation to her perceptions and observations and to the findings she presented at the E-Learning Symposium. Teacher A's work has been chosen for this study from amongst 50 teachers involved in the project because it crystallises and brings into sharp focus key points and themes evident across the entire research project. Teacher A was also chosen because she has proved to be

particularly adept at analysing, articulating and representing her experiences, insights and observations in multimodal ways – orally, in writing, and with images and film. In many ways, Teacher A exemplifies the articulate, evidence-informed and tech-savvy teacher-designer-scholar of the twenty-first century.

The Teacher as Researcher

In an interview at the end of the second year of the project in 2007, Teacher A was prompted to consider how Learning by Design had impacted her teaching and her students. In her response, she repeatedly talked about how all the children were engaged in the unit she was teaching and that even a group of usually disengaged boys ‘wanted to be there ’til the end’. When asked to elaborate, Teacher A said:

It’s empowering for me to teach in these ways and it is empowering for the kids to learn in these ways. It’s really positive ... the response you get from the kids. When you have a class like this one, they are usually quite hard to manage. The boys in particular are quite disengaged and to see them for several weeks in a row want to be there and to be quite disappointed when they were called out for a specialist program was just amazing. Those usually disengaged boys wanted to be there ’til the end, they wanted to talk about it, whereas normally when they have learned something they say, ‘Ah, yeah, I’ve done that.’ You know – been there done that – but now they *still* want to talk about it – it’s a fantastic feeling to know that you have maybe found the key ... Of course, it’s sometimes a little bit harder work but when you see the lights turn on it’s just amazing.

Teacher A talked about the effects of the unit on a boy ‘with special needs’:

He even understands some of the basic principles where he didn’t before and for that little boy the lights turned on. And this is with a boy who has poor memory skills and what he has learned has actually stayed with him for five weeks now and that’s pretty amazing ... it’s just great.

The theme of whole-class engagement was common across many of the teachers involved in the larger ARC-funded project. Each teacher had his or her own story of connecting with usually disengaged children, of children wanting to come to class or working through recess or lunchtime, and stories of particular children whose learning responses had been, for one reason or another, extraordinary.

At a workshop in 2006, Teacher A, who was teaching older children at the time, made reference to a boy whom she ordinarily had to cajole into writing – an extremely reluctant writer. Teacher A noted that the boy was actively engaged throughout a unit of work she had designed, however she was surprised to see him happily, and of his own accord, *writing*. Teacher A deemed this to be so significant that she photographed the usually diffident boy independently writing to give to the boy’s mother because his mother would ‘never have believed it possible’. Teacher A supported this with reference to the boy’s mother ‘being over the moon with his progress – she just couldn’t believe he was the same boy, and claimed he was even better behaved at home!’ Teacher A was clearly pleased with this outcome.

Teacher A’s photograph of her reluctant writer appears to be the beginning, a point of departure, for a more systematic and deliberate approach to collecting multimodal data, including photographs and video recordings, as evidence of learner understanding and transformation. For example, in her Learning Element titled ‘Understanding Simple Unit and Group Fractions’, Teacher A’s first activity involves students working in groups with cubes and blocks ‘to construct or show their understanding of fractions’. Teacher A advises other teacher-users of her design ‘to photograph this part of the activity’ because ‘the photographs can be used for assessment, to determine student involvement or for student portfolios’. This is a significant inclusion by Teacher A because it implies that some shifts in student understanding can be more easily captured in the photographs. The potential to capture this shift in understanding is dependent on the teacher recognising a need to capture and document students at the beginning of something – before any ‘teaching’ has taken place. This is doubly significant because school systems in the USA, Britain and Australia are moving inexorably to evidence-based models of monitoring and tracking student performance. Teacher A’s simple advice also highlights the challenges teachers face in

documenting and demonstrating shifts in student understanding and practice – particularly in the context of developing student multiliteracies and system-decreed ‘essential learnings’ and ‘essential values’.

It became evident in her presentation at the 2007 E-Learning Symposium that Teacher A was using images and film as a deliberate means of documenting, tracking and analysing shifts in embodied student performance, explicitly linking this multimodal evidence to her use of the Learning by Design pedagogies and to her design goals. Teacher A’s teaching was also purposefully multimodal as she organised students into groups to work with ‘blocks, counters, paper and scissors’ as well as ‘Web-based materials and digital maths programs’. At her symposium presentation, she noted that her mathematics Learning Element involved a ‘lot of hands-on work with concrete materials’ and that this was ‘to help manage diversity’. She saw this aspect of her design as being ‘very, very important’ because ‘getting kids that touch and feel meant maths was actually real to them’. Teacher A noted that an observer might see this as being ‘typical early years teaching but there is also a lot of pedagogy that goes behind what you see happening’. This is an important point which Teacher A makes because it demonstrates she is self-aware of her pedagogical focus and design intent. She is also signalling to the observer that deliberate pedagogy and intent sit ‘behind’ the surface of the activities she has designed.

If we return to the beginning point of Teacher A’s somewhat naive act of photographing the reluctant writer, we might also recognise a further challenge. At the level of the individual student, this photograph only has meaning in the context of understanding that boy’s story – his ‘backstory’, as they say in the movies. The photograph only has meaning because it represents a significant shift in *that* boy’s story, a plot twist that has maximum relevance for the boy, his mother and the teacher. It may also represent a turning point in his relationship to learning – particularly his relationship to writing.

Creating and sustaining student engagement throughout the course of a unit of work is both essential to addressing student diversity and evidence that such diversity has been addressed – less than whole-class engagement means some learners are missing out. Teacher A believed that her use of different modalities helped address the diversity of her class, adding that ‘the engagement of the whole class proved that their diverse needs were being met’. However, it is what happens during this prolonged engagement that determines the quality of the learning outcomes and the extent of learner transformation. In what follows, I explore how Teacher A created and sustained student engagement in her early years mathematics unit; how the pedagogies of Learning by Design scaffolded and supported her through the design and teaching of that unit; and how these pedagogies contributed to both teacher and learner transformation.

Teacher A began her symposium presentation by identifying the research questions she had independently set herself to address:

- Can Learning by Design add value to mathematics teaching?
- Can Learning by Design achieve student transformation in mathematical concepts?
- Can Learning by Design help to address student diversity in mathematics learning and teaching?

These questions serve to position Teacher A as a teacher-researcher, someone who is actively looking for and documenting evidence of the effects of shifts in her practice precipitated by Learning by Design and her involvement in the research project. Teacher A describes her students as having ‘a diverse range of skills and knowledge’ and that ‘there are a large number of kids in this particular class with specifically identified academic, behavioural and social needs’. She says these needs ‘tend mostly to show as kids not being engaged in the learning’. Teacher A points out in her presentation that her first challenge with using the Learning by Design framework to plan a mathematics unit was correlating ‘my maths language with the concepts of Learning by Design – to ensure that all the knowledge processes were included and that there was a balance of activities in each process’. This concern for balance and a perceived need to include all of the knowledge processes is in part a product of the Learning by Design framework itself, which prompts teachers to consider and address each of the knowledge processes. Teacher A linked the need to consider each of the knowledge processes to being instrumental in how and why the framework was effective at addressing student diversity.

Pedagogies That Work

In the 2007 interview, Teacher A was firm in her view that the pedagogies of Learning by Design 'work'. When asked if she could explain how and why, Teacher A responded:

Because it makes the knowledge real for the kids. It makes it personal ... and transforming. It's taking this bit of knowledge or skill, applying something else to it and allowing them to meld those two things together so that they have a stronger basis for operating with that concept. I think, for me, the most critical thing was in the fractions unit ... I taught the concept of 'wholes' a lot more explicitly than I would normally teach it – far less focused on using worksheets and stuff. It was done holistically right from the beginning through to really understanding fractions and how they work, including the concepts of denominators and numerators. And to actually see those kids apply those concepts to groups without any support ... Then you know it's working because they have actually got the concepts and it was the concepts that were important.

Learning by Design really pushes you to question what you are doing. I keep asking myself, 'What's the big question here? What is it that they really need to know? What's going to make a difference for them in their learning that they can actually take away and then use again?'

Reviewing and analysing Teacher A's unit of work 'Understanding Simple Unit and Group Fractions' reveals a design which is deliberate, detailed and explicit. This is, in part, a consequence of the design prompts provided by the Learning by Design pedagogical framework – teachers are prompted to identify their learning objectives. In the introduction to the unit, Teacher A has added a section titled 'Set-up and Using Circle Time'. Like a conductor setting the tempo and metre of a musical arrangement, Teacher A sets out and foregrounds the socio-spatial arrangements of students which she recommends for the unit:

This Learning Element is based on cooperative learning approaches. Teaching and learning will be facilitated if student desks are arranged in small groups (4 to 6 students), so that students can discuss their ideas and understandings ... To facilitate discussion and reflection each lesson uses a Circle Time approach.

Teacher A sets out in some detail how teachers can use Circle Time and for what purposes. At her symposium presentation, Teacher A explained that she uses Circle Time 'because it encourages lots of discussion so the kids can actually develop their own concepts and theories'. However, these concepts and theories are scaffolded and prompted throughout Teacher A's design. In her Learning Element, Teacher A provides an image to illustrate and evoke the socio-spatial setting of Circle Time. Part of the circle is shown with one child speaking and others around her listening intently. A hallmark of Teacher A's designs is the detailed notes, explanations and visual cues she provides to support other teachers' understanding and to scaffold their uses of her design. She frequently uses images to highlight important socio-spatial aspects of her practice. These features make Teacher A's designs relatively easy to access and understand, despite the often sophisticated character of the activities and their arrangement. Teacher A pointed out that the purposeful arranging, sequencing and scaffolding of these activities is crucial to the success of the design:

Having good, engaging activities is great but it's not enough. What's really important is how you organise and arrange those activities, so that each one leads to the next, continually creating a base for what is coming and taking advantage of what you have already done. You have to set things up so that the kids are carried along on the learning ... you have to set up and sequence activities so that the kids can make sense of what they are doing and, more importantly, succeed as learners.

This connection between purposeful design and successful learners identified by Teacher A was another common theme in the larger research project.

Teacher as Designer

Teacher A begins her unit with an activity which she labels, using the nomenclature of Learning by Design, 'Experiencing the Known: drawing on prior knowledge and experiences'. This activity calls on the students to use a variety of materials – blocks, counters, shapes, cut-up pieces of paper – to, as Teacher A puts it, 'show their understanding of fractions ... what they already know'. At the E-

Learning Symposium, Teacher A showed an image of four children working with play dough. She noted that ‘the evidence in this picture, if you look closely, clearly shows that the kids didn’t understand that fractions have to be equal parts and this was common across every single group. They did not understand this key idea’. Teacher A described how she questioned the students closely about what they had done with the play dough and challenged them to explain what they had made and why:

Most said ‘I made a half’ or ‘I made a fraction’. They weren’t able to explain or articulate that in mathematical terms or in any more complex language than that, so they couldn’t explain what they meant by a half.

As well as finding out what the learners already know, Teacher A is gathering baseline data to track shifts in learner understanding of the concepts she is teaching. Teacher A described how she then facilitated a number of sessions ‘that were basically focused on learning new information’. Teacher A had students continuing to use the manipulatives – paper, blocks and counters – to address two key questions:

- How do you know this is a whole/half/quarter?
- Why is this not a half/quarter?

She advises users of her Learning Element to lead students through a discussion about the materials from which fractions can be made, suggesting they should be able to list the materials used in the previous class and common foods like cake and pizza. In this way, Teacher A builds bridges from the students’ earlier experience and from their lifeworlds into new information and new experiences. She uses the manipulatives with the children to ‘explore making halves and quarters and trying to make fractions from a variety of different shapes and pieces’ and to address the key questions she has set for the activity in embodied ways. In the pedagogical language of Learning by Design, the students are quite literally ‘Experiencing the New: immersing in new information and experiences’. To underscore the effectiveness of these activities, Teacher A, in her next slide, showed three photographs of individual students, which she described as showing

evidence of the students’ greater understanding of fractions as they explored and discussed the materials and fraction concepts – you can see that the two girls are actually making equal halves and, as they reached that level of understanding, we were able to draw the right language from them, the mathematical language which we discussed and built on.

Teacher A pointed out that she uses ‘a wide range of modalities in “Experiencing the New” including Web-based materials and digital maths programs to consolidate, extend and practice new understandings in different contexts and to cater for the students’ diverse needs and learning styles’. She noted that ‘every single student was engaged and actively participated in discussions around these particular types of learning’. She added that what this demonstrated was that ‘using a range of multimodal approaches catches students’ imagination and keeps them involved in the learning’. She further added that ‘there was never a minute when these kids were not actively involved in every single lesson – it was really exciting’.

Careful examination of Teacher A’s Learning Element reveals that every activity is also carefully orchestrated and arranged in terms of pedagogical intent, use of participative and collaborative tools, and via the socio-spatial dynamics she creates. Teacher A’s use of multimodalities is underpinned by ‘Think–Pair–Shares’ and small-group work; the use of cooperative learning reporters – ‘You will have time to go and talk to students on other tables to see what they have done’; the use of large-group and Circle Time discussions; explicit and specific explanations to students about what they are doing and why; and formative, summative and revisionary check-ins and checkouts. ‘At the end of the lesson’, Teacher A advises users of her Learning Element, ‘in a circle, assist the students in developing a concept map about fractions’.

Every activity in Teacher A’s design is marshalled and harnessed according to her pedagogical intent via the scaffolding of the Learning by Design knowledge processes and supported by participative, inclusive and collaborative tools and through the use of multiple modalities.

Teacher A noted that in ‘Experiencing the New’ she also made use of traditional fraction activities ‘that any primary school teacher would be familiar with such as cutting and folding paper and completing worksheets’. She noted that ‘every activity was aimed at building and consolidating understanding and to gradually move students from concrete representations to visual and

eventually to more abstract representations of fractions'. In this brief explanation, we glimpse Teacher A's thoughtful and deliberate use of multiple modes to engage students and build understanding – each activity carefully selected because of its pedagogical character and capacity for 'building and consolidating understanding'. Teacher A added that these different modalities also helped her to 'gather data to measure the students' learning about fractions and to see how they were going'. Teacher A's use of these different modalities to gather data and to track performance suggests an appreciation of the affordances of various modalities which literally allowed her to 'see how they were going'.

This is significant because it demonstrates that Teacher A is knowingly and deliberately creating the conditions via which she can track performance and gather evidence of learning and, by implication, monitor and evaluate her own performance:

The evidence from my project is that the knowledge processes, incorporating multimodal approaches, provide opportunities for students to achieve deeper learning – learning from which they could generalise. Learning by Design helped me to address diversity in teaching maths. In every single one of the eight lessons, every single student was engaged for every single minute of those lessons and the evidence is that they were learning the whole time. This was supported by the use of a broad range of modalities and, importantly, the students had access to different means of expressing their understanding, including visual, concrete, abstract and verbal. It allowed all students, including those with specific needs, a way to participate and benefit from the learning.

Teacher A went on to describe the way in which she questioned herself about how she achieved these outcomes:

Is this just better teaching? Is it because I slowed down and really looked at it? Is it because we did hands-on stuff? But then I decided it wasn't one thing or another, it was the whole of the approach. I decided it was because of Learning by Design, because if I hadn't been doing Learning by Design, I very much doubt that I would have got to the analysing or the conceptualising that we did. I would have focused on skills – these are the skills you need, here are the experiences that are going to give you the skills – but nothing about how you analyse or conceptualise those experiences and connect them with a theory. That's usually the bit that's missing, the conceptualising and analysing.

When asked if she was initially sceptical about how these pedagogies could be applied in mathematics, Teacher A responded emphatically:

Totally! Totally! ... The fact that it came from multiliteracies suggested that it was more about developing kids' literacies, and people don't think of numeracy as a literacy. However, I really wanted to try it with maths, pure maths, and I was really sceptical even at the end ... But when I sat down to figure out how I would explain what I had done to someone else, and began to analyse it, I realised it was these two things – the conceptualising and the analysing – that the kids were doing that made the difference. And the interesting thing is, I have to go back and change the Learning Element [her Learning by Design teaching plan] because those parts aren't clearly expressed in the Learning Element, but they were very clearly expressed in the way I taught it.

This meant that Teacher A could critically reflect on her own work and recognise and address perceived gaps in her original design, as well as knowing where the impetus was for its success with students:

For me it's a planning tool that suits my way of thinking because I am really interested in quality learning and intellectual understanding – I'm not interested in teaching just for the sake of filling in space. So ... if what I teach is valuable to me, I teach it better. If it's valuable to me, the kids actually see that and we make it explicit to them, we make the value explicit. For the kids, the focus on multimodality is very engaging – we teach in ways that meet a whole diverse range of needs because we are not so focused on sitting with a book and a pencil.

Teacher A has clearly moved beyond the realm of anecdotal stories with compelling evidence of learner transformation afforded by her considered application of multiple pedagogies and purposeful use of multimodal methods.

In this brief case study, we see evidence of a teacher who has successfully adopted Learning by Design as both a design scaffold and as a professional metalanguage, which she confidently uses to consider, explain and discuss her practices. Teacher A's work and her observations and responses suggest that it is possible, using the Learning by Design pedagogical framework, to design learning that is engaging and inclusive of diverse students' needs and interests, learning which promotes belonging and learner transformation. Teacher A's example lends weight to the conclusion that effective teaching is a matter of design.

References

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