Dispositions, disciplines, and marble runs: a case study of resourcefulness

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Abstract: In this paper, three researchers and two teachers have zoomed in on three 'mid-level' episodes of learning in a childcare centre and analyzed them using two lenses: a dispositional lens and a disciplinary (science) practices lens. We wonder how these two perspectives could be combined, in order to provide a coherent and illuminating analysis of the learning and to have something to say about the transactional and progressive processes towards 'being a competent learner' and 'being a scientist' that might be at work here. We have found the notion of 'resourcefulness' to be a useful boundary object; it works differently in the different lenses, but has core features in common. We look back across three documented learning episodes and teacher reflections from an early childhood centre, and consider ways in which 'resourcefulness' can provide a boundary-crossing concept that has value for discussions about learning across educational sectors.

Introduction

Traditionally, outcomes to do with attitudes towards learning, or dispositions, have been fore-grounded in early childhood curriculum discussions, while subject- or discipline-based concerns with knowledge have been fore-grounded in secondary curriculum discussions. Two of the authors of this paper are early childhood teachers, one of the university researchers has a background in early childhood teaching, and the other two have backgrounds in secondary school teaching of science and mathematics. We are all interested in zooming in on particular episodes of learning and teaching in classrooms and early childhood centres, and then zooming out to develop ideas about the ways in which learning trajectories or learning journeys might have been set in motion or strengthened, and what learning opportunities appear to be particularly affording, inviting and engaging for this educational purpose. We all enjoy seeing rich details and the broad patterns within which the details fit: hoping to become both 'tree-wise and forest-wise' (Moss, Phillips, Erickson, Floden, Lather, & Schneider, 2009 p. 504). The university researchers had two lenses on this - learning dispositions and disciplinary practices (in this case of science). This paper focuses firstly on learning dispositions and we investigate troublesome notions such as transfer and authoring. Secondly, a lens of disciplinary practices highlights relationships between children and teachers and artifacts of the environment. We were interested that the early childhood teacher authors appeared to shift easily from one lens to another and, in this paper, we are seeking some common ideas across these two lenses, for analyzing the learning in ways that enrich our ideas about learning journeys and learning pathways.

Learning dispositions as a concept usefully starts with Perkins, Jay & Tishman's (1993) triad of elements for a 'thinking' disposition: inclination, sensitivity to occasion, and ability. Using the triad, dispositions can be summarized as being ready (inclined) willing (sensitive to occasion) and able (having the ability or the knowledge) (Claxton & Carr, 2004). Dispositions turn abilities into action (Ritchhart, 2002): abilities become actions when the learner is generally inclined to apply them, and sees that this might be an appropriate occasion. They appear in the literature under various names: for instance, as habits of mind (Costa & Killick, 2000), mindsets (Dweck, 1999, 2006), key competencies (Rychen & Salganik, 2003), and learning power (Claxton, 2002). They have been seen as the building blocks of a learner identity:

> How shall we deal with Self? ….. I think of Self as a text about how one is situated with respect to others and towards the world – a canonical text about powers and skills and dispositions that change as one's situation changes from young to old, from one kind of setting to another (Bruner, 1996, p. 130)

Here we build on previous research that sets learning disposition into a sociocultural frame (Carr, 2001a, b; Carr, Smith, Duncan, Jones & Lee, 2009), connecting them to situation and setting: to disciplinary practices, and to resources or affordance networks.

Disciplinary practices are specialized "ways of representing knowledge, and ways of thinking and inquiring that come to count as knowledge" (Kelly, Luke & Green, 2008, p. viii). In science, for instance, a valued practice of the discipline is to conduct an experiment and to repeat and refine as a means of generating knowledge. Windschitl, Thompson & Braaten (2008) write about the scientific forms of inquiry associated with

the 'epistemic nature of knowledge'. "Scientists create models in the form of analogies, conceptual drawings, diagrams, graphs, physical constructions, computer simulations" and they use these models for the following forms of inquiry:

> Meaningful learning in school science entails more than accumulating domain knowledge, it requires the appropriation of specialized epistemic discourses that allow students to organize, develop, and evaluate knowledge according to disciplinary standards. (Windschitl et al., 2008, p. 310)

Models are subsets of larger, more comprehensive systems of explanation (i.e. theories) that "provide crucial frames of reference" for *generating* hypotheses or working theories for *testing*, *revising*, *conjecturing* and *explaining* (p. 311-312)

Guiding our analyses is the view that a learning activity is distributed over people, places, and things: the learner as a "person-participating-in-a-practice" (Miller & Goodnow, 1995, p. 8). In order to represent the multidimensional nature of situated activity we draw on Barab and Roth's definition of an affordance network as the "collection of facts, concepts, tools, methods, practices, agendas, commitments, and even people ... that are distributed across time and space and are *viewed* as necessary for the satisfaction of particular goal sets" (2006, p. 6) (italics added). A closely related idea is the notion of a learner as an "agent-acting-with-mediational-means" (Wertsch, 1998, p. 24) where mediational means include language, signs and symbols, and other tools and artifacts. Learners act with mediating tools by "recognising and activating a tool's affordances that are suitable" for a particular purpose or context (McChesney & Cowie, 2008, p. 108). We describe and discuss an episode about Chase rolling marbles down wooden tracks as a means of exploring how learning dispositions and disciplinary practices might inform us around issues of authoritative competence (Greeno, 2006). For example, how might a perspective based on recognizing, activating, and adapting resources encapsulate mediated activity? Finally we highlight some issues around refining these concepts, discuss the notion of 'resourcefulness', and raise further questions that might be explored in different settings.

Background

The episodes that form the data for this paper were included in the Final Report for a three-year research project on strengthening a culture of question-asking and question-posing in an action research project by the teachers and the children (Greerton Early Childhood Centre Team, Carr & Lee, 2008). This was part of a Centre of Innovation programme, funded by the New Zealand Ministry of Education. Children who attend this childcare centre are aged from infancy until the day they go to school (usually on their fifth birthday). Significant features of the centre's practice are: a culture of reflection and critique, a philosophy of shared leadership, and an environment that affords and promotes inquiry. An aspect of the latter is their use of Learning Stories as a formative assessment mediating tool or artifact. Learning Stories are characterized by digital photographs being taken, an episode of learning is described (in text, sometimes dictated by the learner), the learning is analyzed, and suggestions for further work are made. Each Learning Story is digitally stored, printed as artifacts for portfolios, re-visited with the children by the teachers, and sent home to parents and families (Carr, 2001a). Sometimes they are written to the learner, as they were in this case. The Stories here are about Chase, who, by the time he was four years old, owned a number of portfolios of learning episodes in which he was a participant, sometimes working on his own, sometimes working in a group.

The research study involved the sixteen teachers in this centre reflecting on their Learning Stories, writing alternative perspectives, and developing a framework of key features for the affordance network associated with their intention of question-asking and question-posing. The teachers dubbed this framework the 'Threads of Inquiry'. There were six: Continuity, Listening Dialogue, Growing Intelligence, Playfulness, Surprise and Uncertainty, and Real Work. The data for this paper came from three Learning Stories in the Thread of Inquiry entitled 'Continuity' and Robert's reflections on Surprise and Uncertainty. Comments from Robert and Lorraine also come from the concluding chapter of the Final Report.

Robert's Stories

For several months Chase has been exploring the making of 'marble runs' with angled blocks (wedges), wooden tracks and marbles. Robert, one of the teachers, writes two stories about these marble runs. In the first (What it Takes to Get There) he (Robert) had introduced a 'provocation', asking Chase whether the marble would run into a wheeled cart if it was placed at the end of the run. He and Chase began to explore together, and the story continues:

> Chase, you thought this experiment would be OK so we put the cart at the end. We found it too high so first we had to build up the end of the run high enough so the marble could drop into the cart. You tried the marble down the track. Because we had built up the end it ran out of steam before it could get into the cart.

Chase then takes over, and Robert comments:

> And here is where your keenness to experiment and your extensive knowledge of marble runs showed through. As you positioned a block and tried the marble, it still did not make it. You placed a block under the lower end, raising it up, which stopped the marble even further from the cart, this did not faze you at all but with confident persistence you continued to add a block then test, then another and test again until you had success and the marble made it into the cart. I was really impressed with your willingness to meet the challenge getting the marble into the cart, presented even when it took many attempts. Your enthusiasm (for) the task showed through in the way you celebrated by excitedly jumping and laughing when the marble finally went into the cart.

In a second story (How Far Can We Go?), two months later, including photographs of a more complex marble run, Robert writes:

> When I watch you creating one of these marble machines, it is very obvious to me, by the way you test and adjust again and again that you are always asking questions of yourself and your creation and then through testing answering them. …
>
> Also it is not only myself that has noticed your talent at marble machines but also many of the other children as they are emulating your work. In particular I have noted that Dominic's marble creations have a definite Chase influence about them.

He adds a 'Teacher Reflection'; this time the comment is not directly addressed to Chase. Other teachers and Chase's family will read these stories, and re-visit them with Chase.

> It is really great to watch how Chase is building complexity into his marble runs, and his knowledge of what is needed to make the marble follow the track he has created is growing with it. The persistence that is needed to test and retest is a disposition that will always be of use (for) problem solving whatever the task. The social side of the marble tracks cannot be ignored either. The more interesting the track you build, the more others will want to try it out or make one as well, so with limited blocks and space this provides many opportunities for negotiation, compromise, and tolerance.

Lorraine's Story

At about the same time as these stories about the marble runs, Lorraine Sands (the second teacher author of this paper) wrote a story about three children, including Chase, rolling reels (empty electrical cable reels) down a ramp handrail. She called this story 'The Experimenters Continue'. She writes:

> Walking down the ramp is often a place of congestion. Only because it's a good place to experiment with reels and rolling. I think that today as Chase and Tom rolled and chased, rolled and chased, the appeal may have been motivated by their lengthy experimentation with pipes, marble rolling tracks and now electrical reels. They (Chase and Tom) were building their knowledge base as they worked together and alongside each other, calculating speed, distance and trajectory.

Her commentary on the learning that was happening here began with the following comment:

> I think we have experts (like Chase and Tom) who have spent long hours working out their theories, and apprentices (like Dominic) who get captured by the excitement, watch intently and then start experimenting themselves. But practice is a key element to building a knowledge base that is shaped and re-shaped through experimentation, refinement and further risk-taking in related fields – hence the fluid movement between pipes, marble tracks and electrical reels.

Lorraine notes in the documentation that she asked Chase for his 'expert opinion' about why Dominic's wider reel had veered (wobbled) off course.

> He told me immediately, "Cos it's too fat out". And he was exactly right. His endless experimentation had given him the understanding that the inside width of the reel was a critical factor in the trajectory.

Learning dispositions

The teachers here were particularly interested in learning dispositions, which had been a feature of their early childhood curriculum since 1996 (New Zealand Ministry of Education, 1996). The national early childhood curriculum includes a strands 'Exploration'. Learning outcomes (described as a combination of knowledge, skills and attitudes) in this strand include: the ability to make decisions, choose their own materials, and set their own problems; the attitude that not knowing and being uncertain are part of the process of being a good learner; an expectation that they take responsibility for their own learning; the knowledge that trying things out, exploration, and curiosity are important and valued ways of learning. At the same time this strand includes a goal that says: "Children experience an environment where they develop working theories for making sense of the natural, social, physical and material worlds" (p. 82), and the teachers were interested in this too.

In an earlier project Carr and colleagues had taken Perkins' three elements of a 'thinking' disposition (inclination, sensitivity to occasion and ability) into the 'middle' space between the individual and the context, calling on the work of Wertsch, who writes about 'living in the middle'. He has said that "a focus on the mediated action and the cultural tools employed in it makes it possible to live 'in the middle' and to address the sociocultural situatedness of action, power and authority" (Wertsch, 1998 p. 65). We described three processes of mediated action for the construction of learning dispositions, based on Perkins' triad: authoring, recognizing opportunity, and connecting the knowing (Carr et al., 2009). These ideas build on Bourdieu's notion of *habitus* (e.g. Bourdieu 1977, 1990) and owe a considerable debt to Greeno (2006; Greeno & The Middle Schools Mathematics Through Applications Project Group, 1998), Gee (2008) and Lemke (2000). In his 2006 commentary in a special issue of the Journal of the Learning Sciences on transfer of learning, Greeno concludes (p. 546) that "To act effectively in a way that counts as transfer, therefore, involves having or taking authority to go beyond what has been taught", and we have argued that these three processes can include the seeds of learning journeys over time.

Authoring. Greeno (2006, p. 538) describes the conditions for authoring, authoritative and accountable positioning, as aspects of interaction such as crediting individuals with ownership, initiating ideas and topics, and challenging and questioning. Robert emphasizes persistence as a learning disposition, and comments on Chase's persistence that is needed "to test and retest", and, in a comment in the first story, 'What it Takes to Get There', he says "To be able to enter into a task with such enthusiasm and willingness to experiment is a disposition that will make so many of life's challenges easier to meet". In a commentary for the research project on the first story he commented on his observation that for Chase "a setback was just motivation to research new ideas". He interprets Chase's work as "asking questions of yourself". In a commentary for the research project on the What it Takes to Get There episode, Robert comments on what kind of an affordance is a provoking question, and whether in this case it had re-positioned Chase's authority.

> When I first looked at this, I really had to question myself. Did my posing a question about the possibility of the marble making (it to) the cart, actually support Chase in 'question-asking' when it was myself not Chase who posed the question? …. I was just thinking about how glad I was that I held my tongue while I was working with Chase as he was trying to achieve the goal of getting the marble down the marble run and into (the trailer). I found this particularly hard when Chase started to build the run up in the wrong direction".

In a commentary for the research project on the second episode, How Far Can We Go, he said: "There is a definite culture of metered intervention within the (childcare) centre. By this I mean that the teaching team here are very conscious of when and by how much they project themselves into the children's learning. They may choose to set a provocation, or work as a role model, or mentor".

Recognizing opportunity. After Robert had increased the challenge in this activity he reminded Chase that "You thought this experiment would be OK", and he connected the growing complexity of the marble runs with Chase's growing 'knowledge of what is needed': "His knowledge of what is needed to make the marble follow the track he has created is growing with it". He points out that it is not only the teacher "that has noticed your talent at marble machines but also many of the other children as they are emulating your work". Lorraine's story revealed that it was probably the earlier experience by Chase and Tom with water flows (pipes) and marble runs that meant that they recognized the opportunity of combining some other resources - the electrical cable reels and the ramp hand rails - for more investigations of rolling and slopes. They were re-cognizing the resources. We have described this therefore as an example of 'resourcefulness'. This depended on a range of resources being available, and a 'permeable' curriculum that gave permission for unusual and innovative combinations and uses.

Connected knowing. Both teachers commented on the months of practising and experimenting, the frequent episodes of exploring trajectories of rolling and flowing. They connected up the children's funds of knowledge, developed over months of practice with running water down pipes in the sandpit, and rolling marbles down marble-runs. Lorraine specifically connects the learning over time, as does Chase's portfolio of Learning Stories.

Disciplinary practices of science

The construction of models, like marble runs, can be starting points for scientific forms of inquiry and investigation. Windschtl, Thompson & Braaten (2008) comment that "Although different domains in science have their own fundamental questions, methods, and standards for 'what counts' as evidence, they are all engaged in the same core epistemological pursuit – the development of coherent and comprehensive explanations through the testing of models" (p. 313)

In the above episodes, Chase has been developing marble runs as an interesting project, with a purpose (sending the marble into a container along a more and more complex route). From a scientist's eye, these marble runs are also models that afford scientific forms of inquiry and investigation. Chase adjusts the position of the wooden tracks by placing wooden blocks under them. This adjustment process appears to be a repeated

sequence of adding more blocks (thereby adjusting the tracks) and testing with a marble run. Robert, the teacher, identifies the activity as an experiment, and acknowledges Chase's fund of knowledge about marble runs (González, Moll & Amanti, 2005). Here is Chase as scientist, engaged in a disciplinary practice of experimenting. He constructs a ramp and tries it out with a marble run. If unsuccessful, he changes parameters such as the relative heights of the ends of the tracks, or the orientation where the tracks meet, and then tries another marble run. The iterative process of adjusting and testing is at the heart of a valued scientific practice of experimenting. This particular experiment also has a desired end goal. Success is when the marble rolls down the track and drops into the wheeled cart placed at the end of the run. It is a 'eureka' moment for Chase who jumps and laughs when his goal is reached, and we would claim this excitement is also part of the human activity of being a scientist, albeit not often acknowledged in popular images of scientists.

Nested within this practice of experimenting are other aspects of scientific activity. Adjusting one end of the track more than the other changes the angle of inclination so that the track becomes a sloping ramp. It is not always a simple process of just adding blocks to raise one end of the track; depending on the conditions of the context each end of the wooden tracks may need to be raised or lowered. Chase adjusts the ramp by adding and removing different numbers of blocks at either end of the tracks. The process of adding blocks in order to adjust the slope of the ramp also provides visual information for Chase. We claim that this process of adjustment or refinement is a disciplined practice of noticing, and noticing has focus and intention. Intentional noticing is described by Mason as making "a distinction to create foreground and background, to distinguish some 'thing' from its surroundings" (2002, p. 33). We infer that Chase notices aspects of the physical artifacts of the context; the wooden tracks, the marble, the blocks, and even the wheeled cart that was to receive the marble, all have observable material attributes. These attributes are the width and length of the wooden tracks, the design of the sides of the tracks, the roughness of the wooden track, and the size and smoothness of the marble.

Associated with the physical arrangement of the tracks as an inclined plane are the aspects of motion of the marble. Chase has already noticed that the speed of the marble is an affordance of the track-and-marble system because in one of his early attempts, the marble "ran out of steam before it could get into the cart". Robert also comments in the second story:

> This latest design changes direction not once but two or three times; it will often go through tunnels and has a collection point that catches the marble at the end. To do this you explore the concepts of force, acceleration, deflection, trajectory and motion. You have worked out that the marble does not have to go fast and in fact this latest version pictured works best if the marble is rolling down just fast enough so that it will drop from one ramp to the next without overshooting. What I also find interesting about your marble runs, Chase, is that they not only function very well, but are also pleasing to look at. You seem to have a real sense for what is aesthetically pleasing.

There is more than noticing within Chase's activity. He is *recognizing which attributes are important for his experiment, such as the properties of the artifacts*. Properties of tools are affordances and according to Pea (1993), an affordance refers to "the perceived and actual properties of a thing, primarily those functional properties that determine just how the thing could possibly be used" (p. 51). The height and width of the blocks afford different aspects of being a pillar or prop for the tracks, including any limits on the placement and number of blocks used before the pillar becomes unstable. The wooden tracks afford a sloping ramp where the tracks can direct the path of the marble, and the properties of the surfaces, wood and glass, affords motion. Where each wooden track meets both affords and constrains the ramp of aligned wooden tracks. These are affordances of the tools at hand for Chase and by activating the affordances he adjusts and re-adjusts the tools until the marble run is successful. This is a reflexive process where he attends to how the blocks can raise or lower the tracks, then shifts attention to the slope of the tracks, and then back to adjusting the heights of the tracks. When he has constructed a track with the desired slope, then he shifts attention to the trajectory of the marble.

Here Chase is engaged with affordances of the track-and-marble system that are related to phenomena that we identify as aspects of physics. He is noticing, recognizing and activating affordances of the tools or resources that are suitable for his intention, and for his pursuit of scientific forms of inquiry. Recognizing the affordances of a tool plays an important role for anyone adapting the design of a tool for a particular purpose or context, as required in scientific and technological practice. It is a key to innovation and improvisation. "'Being attuned to and activating affordances' can be rephrased as 'resourcefulness', that is, noticing, recognising, recruiting, and adapting the resources of a tool for particular contexts and purposes" (McChesney & Cowie, 2008, p. 109). Particular properties or affordances of tools provide resources, where a tool is activated or re-sourced for further activity.

Concluding comment

Episodes like these may be part of a documented journey about becoming a competent learner, and recognizing what it is to be one. They are also part of a documented journey about becoming a scientist, and recognizing what it is to be one. The marble runs discussed in this paper might be described instances of 'everyday' science, set in a context of an early childhood centre. The documentation process of Learning Stories, however, is an opportunity for the 'scientist's' view to be recorded in text and photographs. The introduction this new artifact into the environment provides a resource that will be revisited by the learner and others, be read back to the learner, and be a topic of conversations more likely to include a scientific discourse. Commentary by Lee, Brown, Brickhouse, Lottero-Perdue, Roth & Tobin (2007) reminds us that

> The repertoires of school are often compartmentalized so that students' otherwise relevant knowledge is not invited and evoked, and the continuity over time is lost to the urgency of the banal moments of everyday life in school, (p. 335)

This did not appear to be so here. The repertoires of this early childhood centre provided opportunities for inviting, evoking, and provoking spaces for the learners' relevant knowledge and experience, foregrounding continuity over time in action, dialogue, and document. As we explored different lenses on these episodes, we came to see a common, if differently conceived, element of 'resourcefulness'. This provided the common ground between the learning dispositions in situation and participation in the forms of scientific inquiry such as model-making, testing and refining working theories (aspects of the disciplinary practices of science). The commonalities were in the recognition of affordances and the re-cognizing of opportunity as a consequence of the experience that developed strategies and knowledges in the domains of disposition and science. The 'play' with pipes, marble runs, and reels provided a dispositional and scientific milieu that had the capacity to shape a learning journey. In our view the episodes illustrated that *being resourceful* is the source of improvising and reinterpreting opportunity. It is an action that is sited 'in the middle' between the cognizing and re-cognizing mind and the affording environment. And it can take learning across the boundaries of place and time.

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