

# EXPERIENCING NUMBER IN A DIGITAL MULTITOUCH ENVIRONMENT

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A seven-year-old boy named Pietro was standing at the whiteboard, in front of his teacher and classmates, describing the history of 9; that is, how that number had been made in *TouchCounts* (TC) [1]. He had carefully drawn ‘herds’ of 3 and 1 and 5 (Figure 1a), while his classmates watched intently. He had also drawn the 9, whose history he wanted to tell, framed in a box evocative of the iPad screen. He then made an in-the-air gesture, as if pinching the 1 and 3 together (Figure 1b). The researcher asked Pietro to explain what he was doing. He replied that he was joining the numbers, but added that he had another way of understanding too. He pointed to an iPad that was on the desk and then turned to the whiteboard again to draw circles, in fuchsia, around the 3 and then the 1 (Figure 1c). The researcher was perplexed, as were the other children, who asked Pietro what he was doing. Pietro explained that the fuchsia circles meant that the herds were *ready* to be joined (Figure 1d).

When a finger is placed on a herd in TC, a fuchsia circle appears. It is a feedback mechanism that indicates that the finger press has been registered. From their initial reactions to Pietro’s drawing, it seemed that his classmates had not noticed this feedback. This is not surprising, since people often fail to notice all aspects of the artefacts they use. And in a sense, the fuchsia circles do not seem to be of much mathematical significance. In contrast, the pinching gesture (see Figure 1b) does seem conceptually important, as an embodied expression of addition, as an operation that ‘joins’, and Pietro had clearly incorporated this gesture from his prior TC interactions. Yet, for Pietro, the fuchsia circle was very important, worth just as much care in his drawing, and seen as a way of understanding. Indeed, as we subsequently watched the video, we came to realise that, while we

were looking for specific mathematical signs (that is, gestures or words), we were extracting these signs from a much deeper and diverse well of potentially meaningful aspects of experience. In particular, Pietro’s encounters with TC, and the arithmetic tasks with which he had engaged prior to this episode, struck us as having significant, *affective* dimensions that we wanted to understand.

In the mathematician and philosopher Alfred North Whitehead’s work, we found some resonance with our own conviction that, in order to understand the nature of Pietro’s experience, we needed to pay closer attention to the ways he was affecting and being affected by TC, but not necessarily through intentional, sensory perception. The tendency to interpret learning experiences as an active subject perceiving or mediating a passive object produces what Whitehead (1929/1978) termed ‘the bifurcation of nature’. Such bifurcation sets apart human consciousness from its environment; it creates the world as an object that is exterior, static and given [2]. Whitehead’s strategy for resisting bifurcation was to take the event, or experience, as the unit of analysis, insisting that, “events do not ‘happen to’ things; rather, events themselves *are* the only things” (Shaviro, 2012, p. 24). An event is “that of which we discern a specific character” (Stengers, 2012, p. 45), which, for Whitehead, is fundamentally affective. Events are affective in the sense that they affect us: the whirling of the projector fan, the smoothness of the whiteboard, the fuchsia glowing of a herd. These are not sensory impressions of sound, touch and sight, but rather vague awarenesses whose meanings are not exhaustible by their particular characters. We thus draw on Whitehead because we find his conjecture about the affective nature of experience resonated with our own sense of

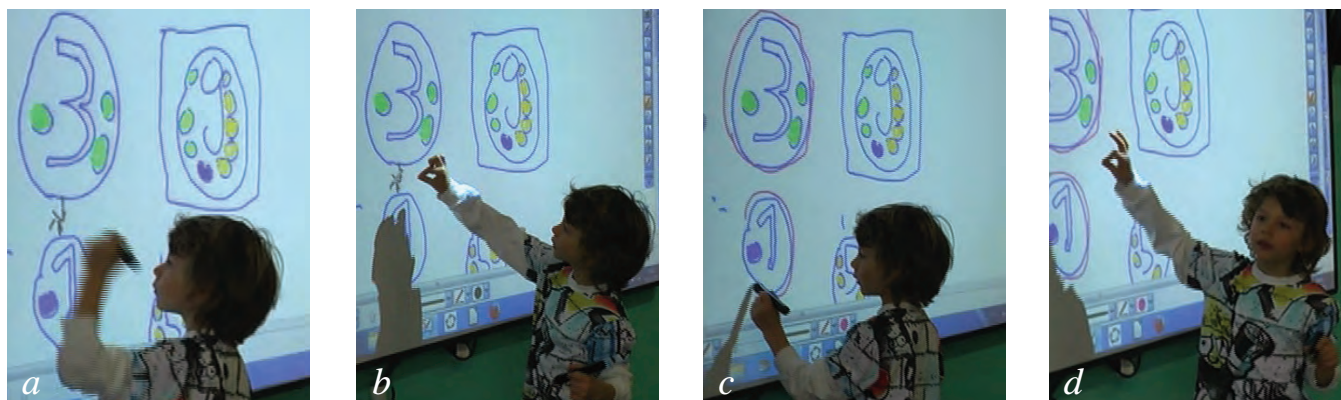


Figure 1. Pietro and the history of 9.

the significance of the circulating affects in this episode. Our concrete problem is, thus, better to understand Pietro's *experiencing* of number, especially as it related to TC, and its affective undertones.

Methodologically, in order to avoid falling into what Whitehead termed the paradigmatic philosophical error, which is to try "to explain a particular fact on the basis of universals" (Stengers, 2012, p. 189), we borrow from his metaphor of the flight of an airplane, which "starts from the ground of particular observation; it makes a flight into the thin air of imaginative generalisation; and it again lands for renewed observation" (Whitehead, 1929/1978, p. 5). Our ground will be selected classroom episodes taken from a teaching experiment conducted in 2014–2015 in a grade 1 classroom in Northern Italy. There were 24 children in the class, including Pietro, and the teaching experiment was designed to experiment with TC.

The episode described above occurred on the seventh day of an eight-day lesson. During the fifth and sixth classes, the students had worked in the Operating world, in which 'herds' can be created, combined and separated through specific screen-contact gestures such as pinching. Herds are cardinal quantities that are labelled with their associated numerals (Figure 2a). Pressing a herd 'highlights' its circumference in fuchsia and pinching two herds together (Figure 2b) produces a new herd that is the sum of the quantities, whose discs retain the colour of the original herds (Figure 2c). The students were challenged to create a specific number in different ways. They were asked to draw their responses, ten of which are shown in Figure 3 (overleaf).

At the end of the sixth class, the teacher showed the picture of three multi-coloured herds (of which one was the 9 of Figure 2d) and offered the children the following task: "Imagine [*pause*] what was there on the iPad before each of these?" This task focused on the inverse operation of determining the 'history' of a multi-coloured herd. The goal was to be able to help the children see that a given number can have different histories, in that they can originate from sums of different numbers, and can therefore be seen as an invariant result of different sums. The children were asked to draw their responses; Figure 3 shows ten of their responses.

We selected the episode of Pietro because, as we watched the video recordings of the classroom sessions, the data seemed to 'glow', a post-qualitative methodological event that MacLure (2013) describes as an emergence of sense, "that exceeds propositional meaning, but also has a decidedly embodied aspect" (p. 661). As we read Whitehead on experience, we made new sense of the data, which motivated the selection of other episodes, which we will describe below.

### Up into the thin air of experience

Whitehead anticipated the posthuman de-centring of human subject [3] by re-balancing the relation between subject and object and refusing to see the subject as the locus of agency or intention. The subject, like any object, is an event. A sculpture is an event; the number 9 is an event. For Whitehead, the act of experience goes from an initial encounter with the objective world and then *ends* by providing a subjective account of it. Whitehead's philosophy is the inversion of Kant's, which describes the process by which subjective data pass into the appearance of an objective world. For Whitehead, it is not the Kantian subject that emerges, but what Whitehead calls the *superject*, which is the subject-object relation. This approach also de-centres the Vygotskian subject that emerges as a self-regulating, psychological entity that mediates and interiorises experience (through gestures, tools, numbers, *etc.*).

As Shaviri writes, "The whole point of Whitehead's philosophy is to free our notions from participation in an epistemological theory of sense-perception" (2012, p. 30). In order to resist the bifurcating logic of mind-body dualism—to avoid the idea that sense impressions are something that happens to the subject, that sense perception is completely subjective—Whitehead argued for a new theory of perception in which perception is the activity of encountering an objective world. When we look outside the window, the green leaves on the tree may be what is lifted to consciousness, but we must not ignore the vague awarenesses of the activities that result in the appearance of those green leaves. In other words, while it can be useful to identify a colour, it is misleading when it is taken to be indicative of the nature of experience. Instead of the sense organs being the vehicle for awareness of sensation (of greenness, of roundness, of sweetness, or loudness), what we experience is 'my perception of those leaves is green'. And we continue on experiencing and expressing ourselves—whether we are conscious of it or not.

With Whitehead, we are less concerned with interiorisation and self-regulation, and more interested in the very activity of encountering an objective world (of whiteboards, iPads, numerals, *etc.*) and we ask: How do the children take up and responds to TC, to the whiteboard, or to the blank paper?

What insights can be gained by focussing on the children's drawings in Figure 3? We can read them as representations of the children's sensory experiences. However, we can also make inferences about those vague awarenesses of experience. For example, the drawings express an awareness of the movement of the herds on the

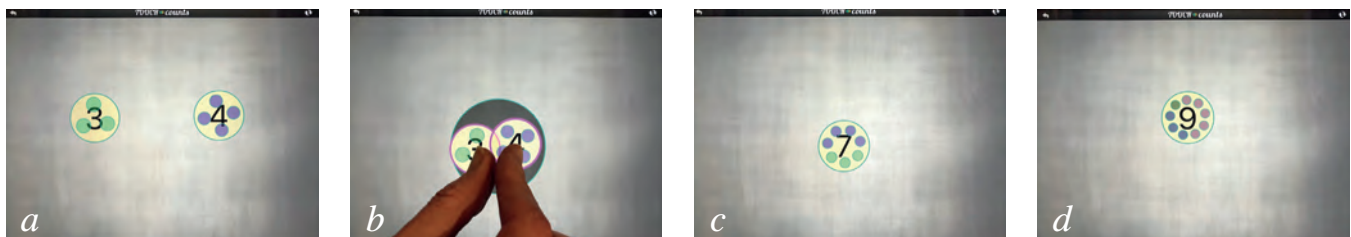


Figure 2. (a) Two herds of 4 and 3; (b) pinching the two herds together; (c) the new herd of 7; the multi-coloured herd of 9.



Figure 3. Drawings of the history of 9.

screen; the hand's implication in the activity; the size of the herds; the distribution of discs within the herds, the variously coloured herds and discs; the background of the screen (its colour and framing). The children are not simply representing what they have seen or done, but instead creating anew, transforming previous encounters into a new event that does not entirely resemble the original. In this case, the drawings do not entirely resemble the original production of 9 on the iPad, not only because the medium has changed, but because new disclosures will be made, that is, new prehensions.

For Whitehead, the term *prehension* describes that which is “non-sensuous perception” (1933/1967, p. 180). Prehensions are not sense perceptions because they are neither a part of cognition nor a sensorimotor response. Whereas apprehensions are conscious, prehensions can arise between people and objects, as well as between inanimate objects (a glacier can prehend the mountain). Prehensions change their modes of existence as they become actualised, which is to say, as they are thought, said, written or drawn. Therefore, we cannot take them as being represented on paper, because

they would have had to have been sensed or known already. For example, the arrowed line between two herds in some of the diagrams are actualisation of a prehension of the fingers tracing a path connecting two herds; the small discs in each herd are an actualisation of a prehension of the herds being filled with coloured discs; the coloured background is an actualisation of a prehension that the herds inhabit a plane that holds them up.

Of course, these three examples are purely speculative, but even in proposing them, we think that we are pointing to something quite significant about experience and, essentially, about what might matter in experience that may be frequently overlooked, or misidentified as epistemological. In fact, in relation to the third speculation, there was a short episode that preceded the Pietro episode, in which the actualisation provides some evidence for the prehension of holding up, as we will now show. This episode occurred in the initial part of the sixth lesson, when the teacher had asked the class to describe what had been done in the previous lesson. A girl named Alice asked to go to the whiteboard. She wrote a small ‘1’ near the



bottom of the whiteboard and then, to the right, a bigger ‘5’ (as in Figure 4a). The difference in size may have been an actualisation of a vague impression from TC that the bigger the number, the bigger the size of the herd. Alice then made a fake pinching gesture with her right hand, fake because she did not actually touch the numerals but gestured close to the whiteboard, as if she were pinching them together. The researcher asked, “What if you had to explain this to a friend in another class, who hasn’t seen what happens on the screen?” Alice moved slightly to the right, to an open area of the whiteboard and wrote ‘3’, then drew a circle around it.

The researcher asked, “What is this circle that you drew there?” Alice responded, “Three inside the bubble”. Asked “which bubble?”, Alice laughed, nodded and responded, “That which keeps it up”, pointing upwards at the board (Figure 4a). She then added “and it doesn’t go down”, now gesturing downward (Figure 4b). Alice then drew a circle around the ‘5’. At this point, silent and facing the board, Alice again used the pinching gesture. The researcher suggested that she use the iPad, in order to help her communicate with her classmates. Smiling, she took the iPad, created a herd of 3 and then a herd of 5 and showed the screen to the class (Figure 4c). The researcher asked, “And now, what will you do?” Alice answered, “I take both of them and I put them close”, gesturing over the iPad, “and so they get put together” (Figure 4d).

When Alice made the circles around the numerals, it was not simply a reproduction of the content of the screen, because the circles seemed to be an actualisation of that which keeps the numerals up, or floating, like a bubble, in a way that made them available to pinch. This vague awareness may have been occasioned by Alice’s experience of the difference between the Operating world, where one pinches herds together, and the Enumerating world, where one touches the screen to make ordinal numbers that then fall off the screen unless they are placed on the shelf. Falling numbers cannot be joined together, but floating ones can.

This example allows us to propose a few ways in which the prehension might matter in this situation. For Alice, it may have been an important way for her to distinguish ordinal from cardinal numbers, which in turn may have infused her experience of number with a prehension of number that when it is not moving away, not changing, it can be joined with another number. The drawing of the circle was spontaneous and enables us to see how the herds affected Alice—giving her a sense of a bubble that contains and holds up—and were affected by her (when she placed her fingers on them to pinch them together).

Here we are focussing on the very process of selection and determination that constitutes experience, which is very much about the encounter of Alice with TC and with number as it is instantiated in TC. We might ask how much it modulates her eventual understanding of number, but we cannot deny that the Alice who understands number is a superject produced from an encounter involving many prehensions including the one that associates numbers that can be added with those that are in bubbles.

In terms of method, we flew into the thin air of imaginative generalisation around the concept of experience, and then returned into the concrete situation of the classroom, in

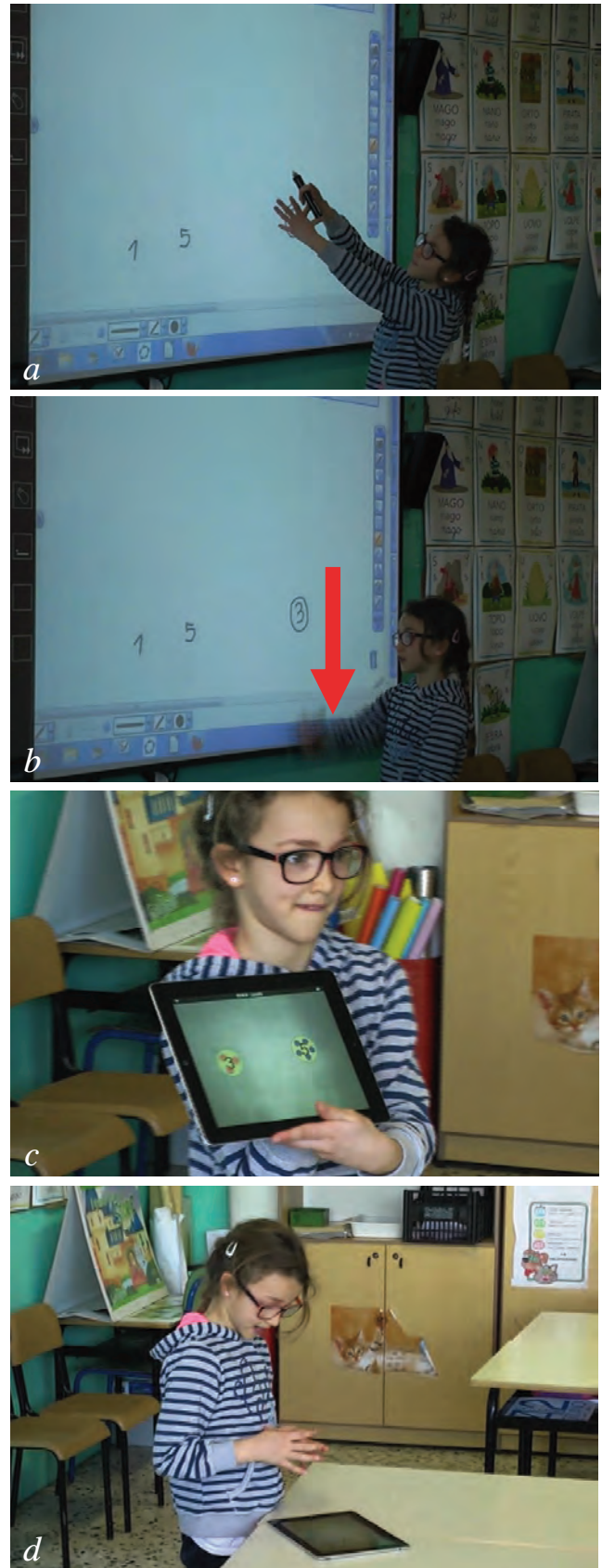


Figure 4. Alice at the whiteboard (a, b) and with the iPad (c, d).

order to create new meanings about the experience of number. We took up the notion of prehension, which helped provide some insight into the nature of Alice’s experience and, in particular, to prehensions that Whitehead described as central to experience. In Alice’s example, as well as in Pietro’s, the experiences are significantly tied to the past. For both, these included, among other things of course, past experiences of using TC. They both involve what Whitehead calls perception in “the mode of causal efficacy” (1933/1967, p. 168), which is a mode of perception of our past experiences—our experiences of having seen something before, having felt something, having inherited something from the past, a memory. It is, as Smith (2010) writes, “the awareness of the causal, physical power of actual entities from our immediate past influencing or conditioning our present moment of becoming” (para. 30). In the example of Alice, the experience of writing on the whiteboard thus includes this perception of past experiences.

To think more about the temporal aspects of Whitehead’s ontology of sense, we now take-off again into the thin air of imaginative generality, where we visit the concept of *feeling*, which is a particular kind of prehension. This will help sharpen our appreciation of the significance of affects in mathematical activity.

### Up into the thin air of feeling

As mentioned above, Whitehead’s interest was in how a subject and object encounter each other, rather than how the subject comes to know the object. He did not reduce the object to the already known or determined. Further, the concept of prehension is devoid of suggestion either of consciousness or representative perception, both of which would fail to resist the bifurcating of nature. Prehension is “a basic element from which springs the self-creation of each temporal occasion” (Whitehead, 1933/1967, p. 238). Prehensions can be positive or negative.

Positive prehensions, which Whitehead called *feelings*, have a valence that leads *towards*. That the fire is hot is not a feeling, but the sense of wanting to get closer to it *is* a feeling, in that it prompts a particular decision of how to act. Negative prehensions are feelings that are not felt and, thus, that perish. This may happen, for example, when there is no vague awareness where there might have been—no vague

awareness of one’s finger touching the screen; of the strength of the touch; of the sounds that are produced by certain touches. For Whitehead, this perishing is just as important as the positive prehensions, since “perishing is the initiation of becoming. How the past perishes is how the future becomes” (p. 238). The classmate of Alice’s who had not prehended the holding-up of number by the bubble, could initiate a new becoming in the experience of Alice’s explanation. In passing “from the immediacy of being into the not-being of immediacy” (p. 237), negative prehensions are not nothing, for they remain as “stubborn fact[s]” (p. 237), in that they were part of experience even if they were not taken up and responded to.

Feelings are not a static property of the situation or of the person, like when we say that a student is anxious or curious. Rather, a feeling is a passing, like a vector, a way, a pulse. In this manner, a feeling offers itself to be felt again, thus becoming, in a sense, objectified as a feeling that can later be repeated. The important point here is to avoid the static dualism in which the feeling is cognised and becomes a thing that can be possessed, then applied in another situation—to avoid thinking of affect in terms of individual, emotional states, as is common in much of the research on the role of affect in mathematics education (Hannula, 2012). Whitehead wanted to be able to account for novelty within a radical monism in such a way that feelings are encounters rather than intrinsic, predetermined relationships. Feeling is irreducible to cognition because it is not something that we already know before the encounter. Feelings change whatever they encounter, even if they are not free to do anything they want, because they conform to the encounter.

With this idea of feeling, we return to the episode of Pietro, with which we started this article. We re-tell it here, in a more detailed manner, in order to be able to draw out some of the prehensions that, we hypothesise, are relevant to Pietro’s mathematical activity. On day seven, the children were involved in a collective discussion led by the researcher in front of the whiteboard, with the iPad on a table in the middle of the room.

In the first part of the discussion, the ‘history’ task of day six was explored through examples of the work of some children, so that various individual productions could be shared. Pietro came first to the whiteboard. He drew ‘9’, a

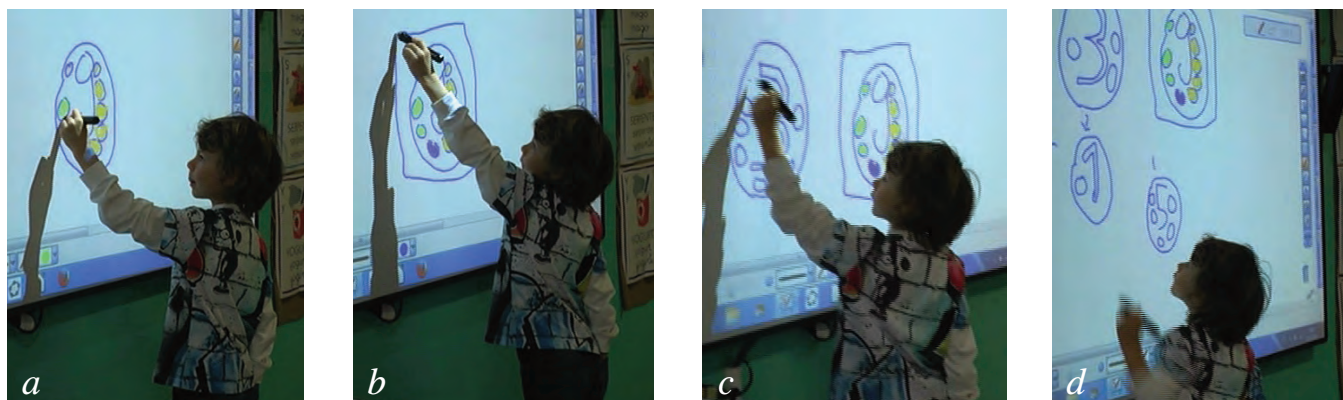


Figure 5. Pietro and the discs of 9, occurring just before the work shown in Figure 1.



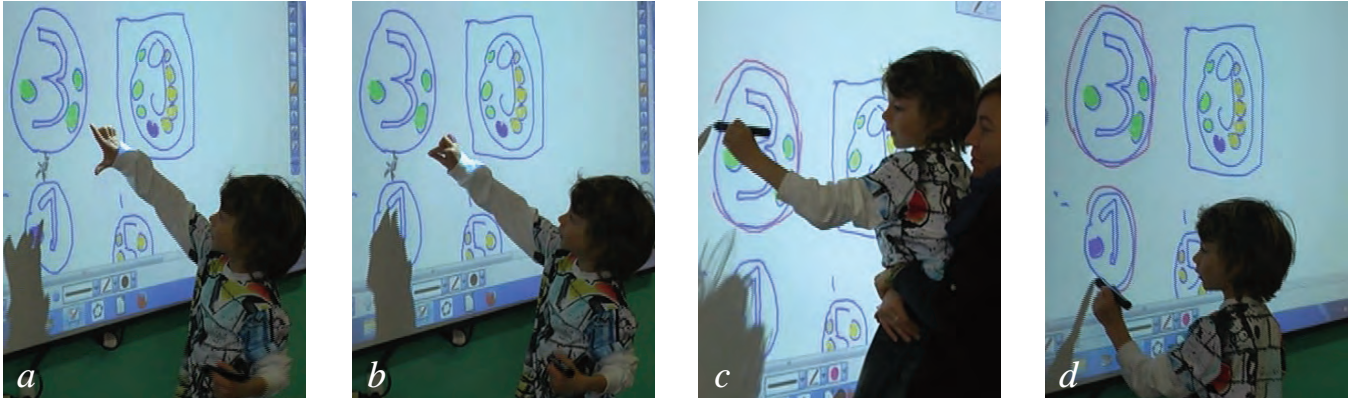


Figure 6. Pietro making the joining gesture and drawing the fuchsia circles.

circle around it and nine coloured discs—five yellow ones, three green ones and one violet one (Figure 5a). He then drew a frame around the herd of 9 (Figure 5b), before proceeding to draw a herd of 3.

While drawing the herd of 3, Pietro added more than three discs (Figure 5c) and Sofia pointed out the error. Pietro restarted drawing the herd of 3, this time carefully attending to the number of discs required. Then, Pietro drew a herd of 1, followed by a herd of 5, each time writing the numeral first, then making the enclosing circle and finally drawing the discs (Figure 5d). Pietro coloured the discs of the three herds. He started with the herd of 5, the one in closest reach, taking a lot of care to colour inside the borders, and did the same precise colouring for the herds of 1 and 3.

The initial ‘more than three discs’ might easily be interpreted as evidence of Pietro being inattentive or sloppy. But if we shift to his experience, it may have been that Pietro was affected by the herd of 9 he had just drawn, which had many discs in it. This conjecture gains strength when we consider the fact that the size of the herd of 3 was just as big as that of 9. But there may instead have been a feeling that TC’s herds are full of discs (indeed, as evident from the bottom right image of Figure 3, which was not Pietro’s, this feeling seems to have been shared by other children), no matter what the numeral was.

We might interpret the encounter here as having involved a feeling of the uniform manner that discs are placed inside

the herds and then of a correspondence between this sense of fullness and the herd’s size. But we might also take as a negative prehension—something that was not taken up and responded by Pietro—the awareness of a relation between the numeral and the number of small discs in the herd, in which case Sofia’s interjection may have provoked a new becoming of Pietro, in which that relationship became actualised.

The drawing took quite a bit of time, although it did not seem to test the patience of Pietro’s classmates. As soon as it was completed, Pietro returned to the pinching between the different herds, introducing arrows (Figure 6a). The two arrows on the whiteboard were drawn facing each other (another mark-making that can be seen in some of the Figure 3 drawings). The researcher asked about the arrows and Pietro responded, while making the pinching gesture shown in Figures 6a and 6b, “because because if you do this,” repeating the joining movement twice, then looking back at the herds of 1 and 3, “um, here is another way”.

The researcher asked, “If you do this? Finish the sentence,” to which Pietro responded “they, they join,” repeating three times the joining gesture, ever quicker, ever closer to the board. He continued, “And there, another way came to me to understand that they join, because in the iPad, a purple circle came”. Sofia questioned, “Purple?”, to which Pietro responds, “Fuchsia”. Pietro then drew fuchsia circles around both the herds of 3 (Figure 6c) and 1 (Figure 6d).

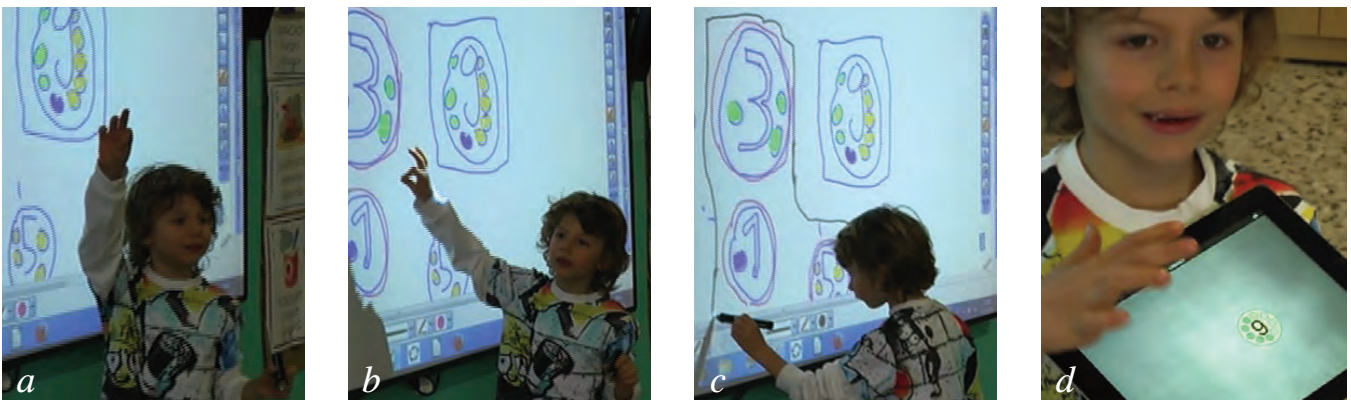


Figure 7. Pietro and the readiness of the herds.

When he talked about another way of understanding the joining, Pietro referred to his previous experience with the iPad, in which “a purple circle came”. It may be that Pietro had not explicitly noticed this fuchsia circle before—indeed, he did not draw it, even though his drawing was very detailed and careful—but that something about the activated herd had been felt, which was prompted by his explanation of what happens when you try to pinch two herds. The arrows that he had drawn, as well as the pinching gesture he made over and over again, may have entailed a re-experiencing of his actions in TC, and a subsequent actualisation of the readiness of herds to be moved, to be pinched, to be turned into something new.

Pietro said little about his encounter with these fuchsia circles. However, the researcher seemed to sense that there was something significant at stake for Pietro. She asked, “Does it assume power?” Other students complained that they did not understand what these fuchsia circles were all about. Pietro said, “When, when you put it together” and made a pinching gesture in the air (Figure 7a). But then Alice offered the following, “Eh, if you press, it comes fuchsia”, showing to have shared a similar feeling. And Pietro pursued, that “if you do so”, making the pinching gesture (Figure 7b), “it makes the fuchsia circle”.

The researcher pointed out that on the board, he had shown that the herds have been pressed, but not that they had been put together. Pietro responded, “Now, I have to finish” and drew a black line around all the herds (Figure 7c). He then picked up the iPad and made herds of 1, 3 and 5, and pinched them all together. Turning to the class, he said, “When you join them”, which he proceeded to do (Figure 7d), “it appears black and aqua green”, pointing to the new number.

The black and aqua green that Pietro referred to can be seen in Figure 2b, which shows the transition moment between when two herds are pressed and when they are pinched into one single herd. Pietro was suddenly invaded by all these feelings of number: the feeling that the numbers were ready, that numbers could be mixed, that numbers are separate *and* combined. Pietro, who understood addition, is a superject emerging from an encounter involving all these positive prehensions, and his interactions with TC, his drawings on the whiteboard, the probing question of the teacher.

We have written about the feeling of readiness that was actualised in the fuchsia circles, which was the “power” of herds to affect Pietro, changing the provisional configuration to a different one. Here we see better how there is a directionality to this feeling, which is specifically to join the herds together, a fact that Pietro insisted on repeatedly with his urgent joining gesture. But it is not enough to press and join, because it is the bringing of the herds into one, into a blur of black and aqua green, that produces the number 9.

In other words, there seems to be some feeling of a greater whole emerging, one that englobes all three herds, as Pietro indicated in his large lasso of Figure 7c, and not just each one of them individually. The feeling of the temporality of the process also came to matter to Pietro. It is a temporality that is, of course, specific to TC and that produces a new, dynamic idea of 9 as a (de-)composition of numbers. The experience of cardinality is different here from the typical

definition of the quantity of objects, because it involves this temporal character, so that some children took up the readiness of numbers and perceived 9 as ever changing in the task, both as the origin and as the terminus.

### On feeling and experience

In Whitehead’s philosophy of organism, every entity partakes in some degree of experience. This article offers the case of how primary school children using a multitouch application for learning number share occasions of experience with number and with addition. Occasions of experience manifest themselves as temporal, provisional (f)acts of togetherness (or of subject-object relations, a jostling of things taking each other up), which are sustained by feelings. For Whitehead, feelings constitute interrelations of occasions of experience, and therefore provide ways of encountering between subjects and objects.

Our analysis of the episodes shows that feelings cannot be reduced to cognition, but instead pulse through the children’s experience of number, producing a particular satisfaction, a particular urge, a particular qualitative sensing. Children and number and iPad and whiteboard take up and respond to each other; they intensively come together, constituting what comes to be most vivid and important in experiencing number or addition in this particular context.

The central, active role of TC, which gives new ways of encountering mathematical concepts, is clearly valued here, allowing us to study what it elicits for learners and how it can affect mathematical learning. Significantly, it is in the children’s drawings that many feelings seemed to surface, to repeat and to shed light on the interactions and interrelations that mattered in the past and matter for the future, opening up possibilities of new prehensions. It is this affective dimension that constituted the significance and glow of experience of number for Pietro, for Alice and for their classmates.

In addition, students emerge as superjects out of the experience, rather than experience being what happens to them. It is not the subject that has an interiorised experience so much as it is the experience that produces a new subject; feelings precede the subject. The subject is thus “best described as the integration (in a quasi-mathematical sense), or as the ‘end’ (both sequentially and causally), of the former. The subject is solicited by the feelings that comprise it; it only comes to be through those feelings. It is not a substance, but a process” (Shaviro, 2009, p. 12). Feeling thus subsides beneath or before any interests or beliefs or motivations, and intention.

In all of this, it is the manner of the encounter, of the togetherness, of the taking up and responding to each other, that is crucial and vivid for the children. There are things about TC that are objective and entirely determinate (it produces coloured discs and not squares, it provides accurate sums, it is not voice-activated, *etc.*), which constrain how it can be taken up by a learner, but there is always some wiggle room, some indeterminacy, some kind of choice in terms of how learners and TC take each other up, and therefore how feelings of number will both circulate and disperse.



## Notes

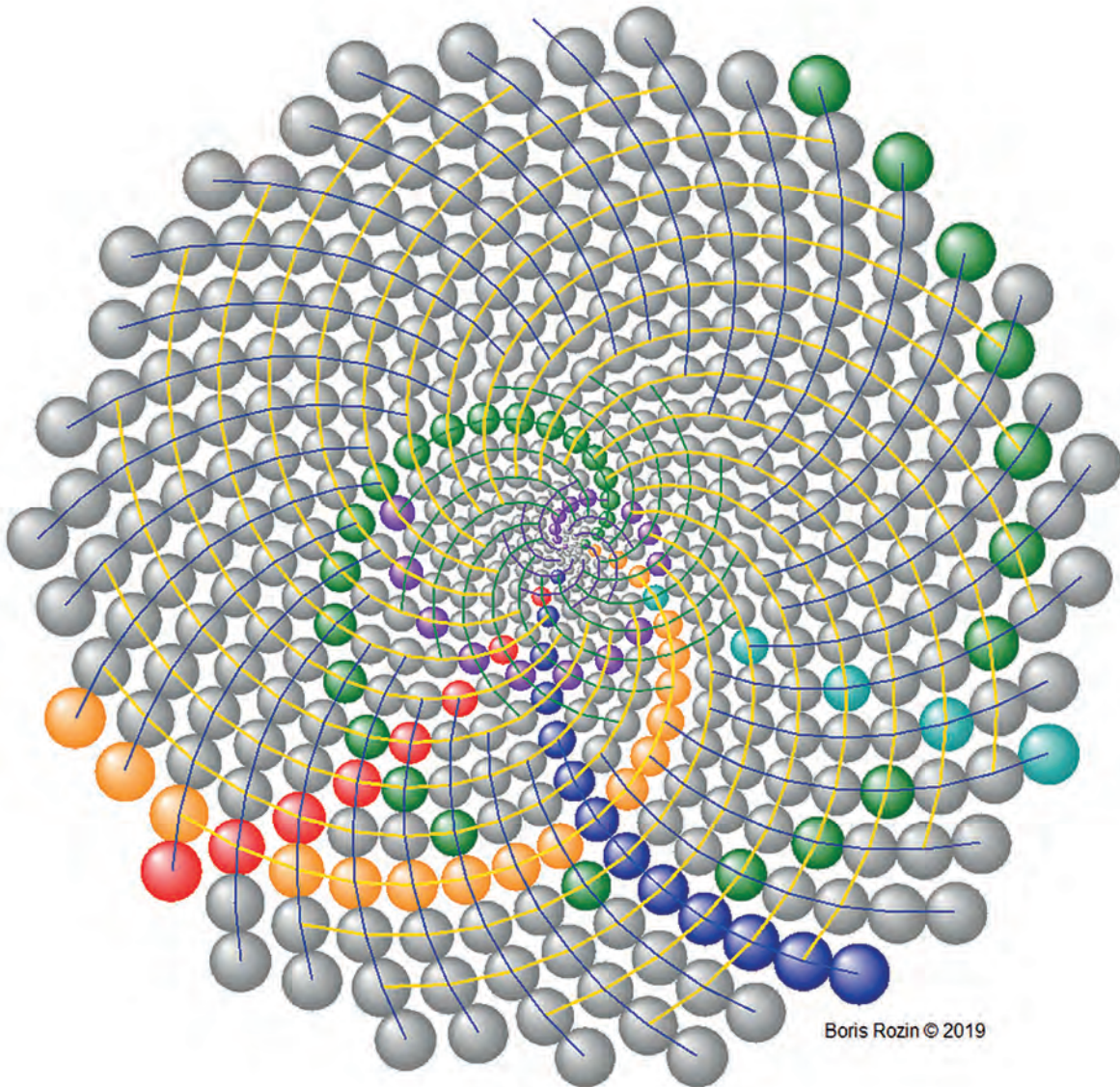
[1] See Sinclair and Pimm (2015) or <http://www.touchcounts.ca> for a more detailed description of *TouchCounts*.

[2] Whitehead's process ontology shares insights with longstanding indigenous philosophies that stress relationality and non-human agency (e.g., Todd, 2014). We have chosen to use Whitehead for the particular concept of prehension, as it relates to affect, which is discussed in the next section.

[3] For Whitehead, experiences are not the sole purview of humans. Even a rock and even an electron have experiences. His philosophy is non-anthropocentric.

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