arithmetical and the pictorial registers. They eventually even feel motivated to try to predict the dynamics, given m and k: the existence of an ubiquitous orbit, for instance. This translation between registers, often involving metaphorization, appears also in other contexts (Diaz-Rojas & Soto-Andrade 2017).

Conclusion

« 12 » In our view, the target article is indeed a commendable contribution to the much-needed exploration of the path less trodden of enactivist didactics of mathematics. It provides a fine-grained analysis of a problematizing dynamics, arising under very specific conditions, in some sense closer to laboratory conditions than to a classroom environment. To this end the authors felicitously take advantage of Ingold's pathways and meshwork metaphors. Their research also has the virtue of constituting a suggestive trigger for further theory building and experimenting, in particular, contrasting their findings with the dynamics arising in a classroom environment, with a teacher-observer assuming some sort of role and students of various backgrounds.

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Authors' Response

Flying Kites and the Textility of Problematizing

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> Abstract • We briefly discuss how far we take metaphors for learning or doing mathematics while challenging the descriptive-prescriptive paradigm in favor of a larger view of research and language (use) emphasizing the *evocative* and *provocative* texture of our work and Ingold's writing. In so doing, we also bring forth an ethical dimension to research writing, which may help situate what we did *not* present, discuss and suggest in the target article: missing fragments, students' backgrounds, teachers' potential roles and direct implications or recommendations, for example. Finally, we also offer a reflection on how our study contributes to research through both its similarities to and distinctions from other conceptualisations.

« 1 » Helen Keller once wrote beautifully that "life is either a daring adventure or nothing" (Keller 1941: 51). Sharing our study on problematizing following Tim Ingold's work, we were aware that readers would challenge what we have to offer. We anticipated that our commentators would ask how far we (should) take notions such as "all doing is knowing" (**Norton** Q1) and Ingold's metaphors of wayfaring and pathways (**Reid** Q1), and we are not surprised by the desire to know more about the students, and what took place before and after the exposed fragments (**Cifarelli** Q2; **Sevim** Q1; **Soto-Andrade** & **Yáñez-Aburto** Q1). In submitting this article, we also considered that we might be challenged regarding what we consider mathematical (**Cifarelli** Q1; **Soto-Andrade** & **Yáñez-Aburto** Q2). Finally, we also expected questions regarding how our conceptualization differs from other perspectives (Norton Q2; Reid Q2), and how this might be helpful to teachers or mathematics educators (Banting §9; Cifarelli §8). So, why did we submit and publish this article anyway?

« 2 » In his book, *Making*, Ingold discusses constructing and flying kites with his students, and the experience of the "dance of animacy" (Ingold 2013: 101) of kite, flyer and air. Similarly, we crafted our target article and sent it into the sky hoping good winds would make it fly, all the while conscious of how those winds might forcefully stretch it, reveal its weaknesses, and perhaps quickly tear our craft apart. However, we wanted the handmade nature of a paper kite: not an (allegedly) safe, strong, hard and cold airplane; something closer to life, fragile, tentative, and exhibiting motion all around. We wanted something more akin to works of art than products of science, something that looks or feels unfinished, something to nourish and grow… mirroring, in a way, the sort of attention to mathematical problematizing Ingold has helped *us* adopt and appreciate. So, now the kite flies, the wind blows, and we do our best to hold it together, to follow the flow, to embrace its power by maintaining just enough tension. Again, taking risks, for, following Keller, writing research is either a daring adventure or nothing.

« 3 » In the following sections, we briefly address the questions and observations offered in the open peer commentaries. We would also like to express our gratitude for the time and attention the commentators gave to our work, and the risks of being challenged they themselves took. By expressing their likes and dislikes, their doubts and confidence, their questions and interpretation, it feels to us as if they are themselves flying commentaries alongside our article. Thank you.

What do we mean?

« 4 » Trying to engage with complex phenomena at an epistemological level in a short space comes with a struggle of making sense. No matter how close we are as a community of scholars, linked by a passion for constructivist and enactivist ideas, the powerful vagueness of language that makes it possible to communicate also opens us to confusion and disagreement. When Anderson Norton (Q1) asks how (strictly) we interpret Humberto Maturana and Francisco Varela's "all doing is knowing, and all knowing is doing" (1992: 26), we are caught in the loop of adding words to words, hoping that saying more will get us closer to what feels right, while perhaps exposing ourselves to creating more confusion. Speaking of pathways, meshworks and knots together with wayfaring allows us to discuss phenomena but also raises questions about the meaning of some words and whether to distinguish verbs and nouns (Reid Q1). Words, after all, are not fixed and immutable but a way to express: they can and do change and adapt.

« 5 » In answer, we do take the enactivist saying quite seriously, with the broadest take on what "doing" and "knowing" might allude to. For us, doing is not merely what we see when a person draws a circle, writes an equation, raises her hand or speaks a word. Thinking is also, in our view, a form of doing (see, for example, Roth & Maheux 2015), and knowing is similarly infused with the active flow of being and becoming, large enough to accommodate the growing consciousness of "knowing in doing" and the case of "knowing someone," for instance.

« 6 » Regarding the very sensitive issue of attending to words, it might have been preferable, as David Reid points out (§§2–4), to limit ourselves to verbs. The verbalisation of nouns such as pathway and meshwork (knot is already a verb) into terms like pathmaking and meshworking might better communicate the vibrant nature of the students' journey. However, we wanted to stay relatively close to Ingold's writings, trying out his words and ideas to move ourselves forward. It is possible to read journal articles and poems in very different ways, with a different attitude towards language and communication. As we see it, Ingold chooses to use words like pathway, meshwork and knot not because they better *represent* phenomena, but because they are more *evocative* of their fluid, ever-changing being and becoming.

« 7 » The quote presented by Reid in §6 also somehow suffers from the noun/verb tension he highlights in Ingold's writing: in enactivist literature, organisms or living unities are not supposed to be taken as static entities, but as active processes, dynamic relationships between elements (that we distinguish as internal and external components). If we commit to the idea that being something literally *is* doing something, is using verbs versus nouns still an issue? For us, the "limitation" of Maturana and Varela's language that Reid's Q2 asks us to identify might rest in its evocative power. Coming from biology, Maturana and Varela provide us with a certain set of metaphors, which they patiently deconstruct, but which still orient us in a particular way. There is no doubt for us that Ingold's ideas strongly resonate with enactivist conceptualizations (and this is why it made sense to present them in *Constructivist Foundations*). However, his metaphors seem to us radically different from those coming from biology, and perhaps closer to everyday human experience. Enactivist terminology speaks of everyday human experience in terms of organisms, unities, systems, or behavioural domains (to give some examples). Even the notion of an "observer" is closely related to how biologists (such as Maturana and Varela) work with microscopes (Maturana 2002). Ingold's expressions are rooted in different kinds of experiences, those of a "maker," like that of turning the bricks of a building into a home by inhabiting it, or street signs and potholes into a journey, or actions and words into mathematical pathways (problematizing).

When is enough, or the art of filling gaps

« 8 » When it comes to talking about events or to discussing a phenomenon, we make choices about what seems a reasonable amount of information to present. Writing our target article, we considered saying more about the background and previous mathematical experiences of the students (Soto-Andrade & Yáñez-Aburto Q1), on how their exploration of an "anticlockwise throw" led to a discussion of odd numbers (Sevim Q1), and presenting more of their journeying toward a "rule" at the end of the lesson (Cifarelli Q2). Providing information on these doings would be straight forward, however, in our understanding Ingold is resistant to objectification. Turning pathways into a series of steps between objects therefore directly concerns our ethics and so first we need to take a detour through Nat Banting's ethical meditation.

« 9 » **Banting** conceptualizes the enactivist understanding of the observers as enmeshed participants: His mention of "intentional" ethics wisely insists that we do not merely "capture" students' lived journey, but are "fully complicit within it" (§3, §8). This is closely aligned with our view on classroom research (Maheux, Roth & Thom 2010; Maheux & Roth 2012) and teaching (Maheux & Roth 2014), giving major attention to the notion of "being-with" (the notion that selfhood is contingent on the experience of otherness and community), experiencing the journey with the students. In this particular case, we feel our ethical engagements are at the forefront of the article, as we specifically focus on students' problematizing as a journey, and explicitly draw attention to how we use both speech and full-body movement in our investigation. The slow-paced tracing out of the students' wayfaring makes the hand involved in the drawing as visible as the pathway itself (the word "investigate" comes from *in-* "into" + *vestigare* "track, trace out"), thus acknowledging our observer's perspective (as pointed out by **Reid** §1). And as researchers-writers-observers, we are not offering an outline of "what took place," nor an account in which we appear to erase ourselves, but what Ingold calls "the textility of making": the sensuous experience of things being made (like wayfarers making their way through the terrain) as opposed to the hylomorphic model privileging abstract forms and homogenized material (Ingold 2010: 92). Accordingly, we particularly orient our work as researchers towards *stimulation* rather than *simulation*: the textility of writing opposed to the recreation of events (e.g., what took place in that room that day), drawing on traces of these events to keep them alive and provoke others (readers) to act and in return, to respond to them (Roth & Maheux 2015). Contrary to **Norton**'s impression (§7), we consider our work *provocative* rather than merely descriptive.

« 10 » Emphasizing the textility of the text also connects with our interest in the language and metaphors offered by Ingold. **Reid**'s analysis of Ala and Chas's interaction (§§9–12) tends to focus on describing entities and ascribing intentions, emotions and an understanding. The cautious parenthesis he keeps open warns us that all that follows is the work of an observer (§8), but for us this still easily gets forgotten when one reads something like "Perhaps [Chas] is feeling discontented" or "Ala reacts positively to Chas's move and adds to it by coming to understand" (§9). Trying to avoid such ascriptions we hoped to find in the evocative language of Ingold a different way of attending to what is said or done, and a means to keep us from reifying the lived journey into a series of moments. For us this is an essential ethical move in regard to research: trying not to map out the territory for readers, but walking with them through a fragment of it, insisting on relationships and allowing room for things to emerge from what follows. From Ingold's perspective we are not looking backward from a finished product (the hylomorphic model of making) but forward on the journey to a gradually disclosed horizon.

« 11 » That said, as **Banting** points out (§3), our article does not consider the teacher-observer's journey. We also do not specifically reflect on where the students are coming from (**Soto-Andrade & Yáñez-Aburto** Q1), nor discuss how the two of us came to write a study on mathematical problematizing. And the same goes in relation to the students' background or how they came to consider odd numbers (**Sevim** Q1) and later formulated a "rule" (**Cifarelli** Q2). How are these journeys entwined with the pathways, meshwork, and knots we see students form in our target article? What can be said about the students' histories (in which they may or may not have commonly engaged with this type of mathematical problem, and may or may not have often played ball games[1])? What might we see from the knotting, meshing and pathwaying that took them to odd numbers and the formulation of a rule?

« 12 » The students problematized and travelled a variety of pathways between and after the two fragments we present. Before they got to odd numbers, they acted out games two more times, discussed why different games do or do not "work" (e.g., one place jump always works), compared numbers of jumps and people, and came up with "formulas" in terms of even and uneven numbers (e.g., odd number of jumps and people works). In addition, key moments in their journey toward formulating a rule involved discussing their observations in terms of how the numbers of jumps and people divide one another. Although these are some of the elements that became part of the students' pathways, to say that they show us how events *led* students to odd numbers and their final "rule" would be misleading. Ingold (2010) explains that the "things" we create do not arise because we travel from A to B, but emerge from the interweaving of pathways and movements. We observed this interweaving as students repeated and refined verbalizations and movements, which were first seen in the first fragment (transcript lines 1–13 in §18). In order to communicate how the students "got there," a full story needs to be told: a narrative, a story of a journey, because what matters to us are not the steps joining A to B, but the weaving and movements themselves. And so, although we do acknowledge students' unique histories and diverse contribution to problematizing, a shift of attention prevents us from describing these as the "students' own images" or "conceptions" (**Norton** §4) or even reconstructing actions as a series of events of Ala's or Chas's problematizing (**Reid** §§10f). We do not ignore them, as **Banting** seems to put it (§9) but, on the contrary, see them as ascriptions that seem to delete the contingent moment-to-moment making of images, conceptualizations, and problematizations.

Same same, but different

« 13 » Heraclitus allegedly claimed that "No one ever steps in the same river twice." Yet, we can see ourselves stepping in the Saint-Laurence or the Waikato rivers once, and twice. We can call the being "oneself," the movement "a step," and the ever-changing flow of water "the Saint-Laurence" or "the Waikato." Being the same and different is hard to untangle. Is our suggestion to observe students doing mathematics in terms of problematizing as wayfaring the

1| In a nutshell, if we must: All students completed secondary schooling at different schools. Mathematics teaching in New Zealand secondary schools is variably based on teaching as lecture, often with students working individually, and some group work and solving of more open prompts (group work is a common teaching activity in primary and middle school mathematics classes).

same as or different from other conceptualizations? Enactivist literature talks about structure, organisation, components, but also about reproduction and autopoiesis (e.g., Maturana & Varela 1992: 47). How does our conceptualization, to attend to and talk about action, interaction, and mathematics, differ from other analyses in the field (**Norton** Q2)? Ingold (2010) occasionally turns to Jacques Deleuze to explain his thinking. In *Difference and Repetition* (1968), Deleuze argues that difference is always present, even in the drab repetition of words, for example. When we write "same same," the temporal difference is enough for special meaning to emerge: Maybe it is a mistake, maybe it is an expression evoking the idea that "nothing changes," maybe there is a word missing! For Ingold no two strokes of a carpenter's sawing are the same. Movements are always changing, adapting, improvising with the flows of saw, wood and carpenter's body. So even if for some it seems we are "saying the same thing," we are still offering something more. Especially if we consider, as Deleuze argues, repetition as a way of becoming. Repetition is always difference, and difference is how meaning occurs (Derrida 1967: 49). And so, one could argue that mathematics *is* (in the active, verbal sense) mathematics by slowly becoming (itself), as immemorial pseudo-mathematical doings become ever-specializing practices and systems of ideas.

« 14 » We would like to connect this with **Volkan Sevim**'s (§6) discussion on processes becoming objects, and **Victor Cifarelli**'s Q1 on the results of seemingly simple algebraic manipulations. Thinking in terms of problematization, how can moving from $2x - 2 = 0$ to $2x = 2$ and taking up that equation be seen as "posing a new problem"? One simple answer is that despite the purported overall orientation staying the same, "isolating the x" in the first case can mean "having only the x term(s) on one side," and in the second (moving to $x = 1$) something like "getting rid of the x's coefficient." Let's also note that these little "problems" could have emerged in a different order (moving first to $x - 1 = 0$). Looking at those moves as part of a journey, we become aware that the so-called intention to "isolate the x" *could* have been replaced after the first manipulation. Seeing something like $2x = 2$ or $x - 1 = 0$ might be enough for someone to declare that the value of x must be 1 without carrying the plan on to its end. Problematizing emphasizes the possibility (and the possibilities) of such bifurcations when one walks towards a progressively disclosed horizon. We do not intend to make ontological statements about "what is," but seek to offer a manner of attending to students' doing: *what if we were to look at students' work in terms of problematizing as wayfaring, path-making and knotting*?

« 15 » Describing a set of actions as "solving for x," one is caught, Ingold would argue, in the logic of inversion: flattening the rich and textured flow of making one's way through (problematizing) in favour of a rigid procedure labelled a "strategy," and calling it a day. Slowing down the pace and observing the making of what a distant observer might want to call "isolating the x" or "u substitution" (which may say more about the observer than the participants) we come to see things (strategies, expressions, steps, etc.) not as "objects" but always in terms of the flows through which they come forth. Ingold writes that things are never ob-jects "already thrown" at us (Latin *ob-* "in the way of" + *jacere* "to throw"), but "*are* in the throwing" (Ingold 2010: 95),[2] and adds:

> "What we had thought to be an object was revealed as what I would call a *thing*. And the thing about things, if you will, is that far from standing before us as a fait accompli, complete in itself, each is a 'going on' – or better, a place where several goings on become entwined." (ibid: 96)

« 16 » Transforming $(x + 5)^2 + (x + 5) = 4$ into $u^2 + u = 4$, does one merely swallow a pill and find one's thirst quenched, or does one conjure forces that are already in the work, and entwine them into one's problematizing? Since not everybody would make such a fluent move, it shows clearly that "x + 5" has to be *made* an "object." What matters to Ingold, and to us, is not the ontological status of that "$x + 5$," but the *making*, and to study this making as a "place where several goings on become entwined." Even if we see that "$x + 5$" as an object (**Sevim** §8), there is still a process at play and *that* is what we are interested in. From Ingold's perspective, we consider the recognition of an opportunity to substitute in $(x + 5)^2 + (x + 5) = 4$ as an instance of being swept into the familiar-to-us current of working with equations in such a way. Ingold (2010) uses the example of creating a piece of art to help us see that if we can, of course, describe this as an agent imposing form upon matter, it is also possible to call out such an interpretation, and insist that the equation itself imposed the move on us (what else can we do?). In contrast, approaching the event as part of a journey (e.g., of problematizing) means, turning our attention to a radically different direction: thinking in terms of forces at play for "perhaps the key to the ontology of making is to be found in a length of twine" (ibid: 100).

The iceberg

« 17 » Lesser known of "Murphy's laws" is that whenever you set out to do something, something else must be done first. So how do we ever get to do anything? Our impression is that current conceptualizations of mathematical activity tend to silence this conundrum, insisting on the necessity to "explain and predict phenomena" (**Norton** §7) and to derive from this tools or recommendations for teachers (**Banting** §9; **Cifarelli** §8).

« 18 » Of course, it is possible to create what **Norton** calls "models of students' cognition" (§3) on which to base our interactions with a given student at a given moment… just like being acquainted with u-substitution can open up an interesting way to engage with a given expression at a given moment. However, if we carefully look at how a teacher responds to a student, we might once again see that before using such models something else must be done first: you might recognize something in what the student did and ask them about it ("Ooh, what'd you do there?"), offer a new-yet-similar prompt ("So I wonder if you could do…"), insist they should try to validate their answer while asking what they did ("How'd you get that?"), and – quite importantly – identify all this as a case of using a model to productively interact with the student. It is only at the end

2| Ingold briefly discusses the subject and object duality by insisting, as we see, on the moving nature of being. We sense a distinction with a predominantly relational approach (e.g., in terms of co-emergence), but Ingold unfortunately does not dive deep into the epistemological significance of his conceptualization.

of a journey, however, that you are able to look back and say "that's what the teacher did, that's what happened." As mentioned earlier, we agree here with Banting's notion of the teacher as being "fully complicit" (§3) with the students' problematizing. Hence, we also want to see teaching as wayfaring, and intervening "in a world that is continually 'on the boil'" (Ingold 2010: 94). Accordingly, the "special attention" we give a teacher considers their unique history and, thus, their role in the classroom, and would focus not on tools to use, like models or steps to follow, but on the weaving of pathways, the knotting and the meshwork that occurs in all that must be done.

« 19 » How an analysis such as ours might contribute to improve teaching and learning is another story. Banting questions the "relevance to the mathematics classroom" (§9), while insisting that more attention should be given to how teachers may be part of the students' journeys. In a similar vein, Cifarelli asks for recommendations for teaching and learning (§8). The approach we offer clearly complexifies rather than simplifies our understanding of classroom mathematical activity. For us, this means better appreciating students, teachers and their mathematical activity: a worthy aspiration that expands what Norton names as "the aim" of research in mathematics education (§7). Is there a chance that, through such appreciation, educators and administrators might become aware of the benefit of slowing down: turning away from what students should learn and making more room for what they do? Might focusing on how things occur in the mathematics classroom and investigating them as the knotting and meshworking of pathways help teachers do all-that-must-be-done first. Could this focus on doing support teachers to problematize and look forward with the students so that problematizing keeps occurring as they work towards the ever opening horizon (Reid §13)? Could all this lead or help some teachers to promote the use of prompts that might open rich territory for students to explore (Cifarelli §8)?

« 20 » In their Q2, Jorge Soto-Andrade and Alexandra Yáñez-Aburto ask if we see the mathematical activity presented in the study as just "the tip of the iceberg," and if so: what would the iceberg be? Ingold invites us to look at mathematics not as something out there (standing still), but as a making, and as something that is continuously being made. Our study is a brief exploration of such making. We have all heard of classrooms in which students are quickly exposed to some mathematical ideas and asked to memorize techniques: whether we agree or not, these lessons present a certain face of what doing mathematics can mean. On closer inspection, these classrooms might reveal more that we expect. In our study, we try to reveal the texture of two fragments of the specific building that took place in a room, on a given day. Although this might become more, currently we simply suggest the reader consider our offering as a kite that is flying into the grand interweaving and adventure of what we call doing mathematics.

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