# THE RHYTHM OF TOUCHCOUNTS: COUNTING ON TECHNOLOGY

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*This research reports on a class of grade one students engaging with number concepts using the iPad application TouchCounts. It is theorized that students develop understandings of number based on a materially engagement with both social and material resources. Rhythm is the fundamental unit of analysis used to attend to student engagement with TouchCounts. A class activity as well as three students working together will be analyzed in terms of emerging rhythms. It is concluded that rhythm is an emergence of form, modeling and aligning with the mathematical notions of number.*

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Early learning of number is significant for future success in mathematics (Libertus, Feigenson & Halberda, 2011). Concepts, ranging from counting and subitising to skip counting, are important in early development of number sense as a foundation for higher development. Students, however, find number concepts difficult (Lockwood, 2012) partly because they often do not have many ways of engaging with number. For example, when children learn to count, they often learn a song in the form of the audible sounds, 'one', 'two', 'three', and so on. While this method can be a good starting point for learning counting, it is linear and only supports an audible approach to counting. New technologies provide new opportunities for students to become more closely engaged with mathematical concepts.

New technologies such as the iPad, including the numerous applications that can be used on this platform, provide new and unique ways of engagement for students. Multi-modal approaches that include embodied actions such as gestures can help support the learning of number by allowing different ways to interact. In this study, the application *TouchCounts* (Sinclair & Jackiw, 2011) is used because it provides an open-ended experiential approach to interacting with number. Pappert (1980) drew on this notion of learning with expressive technologies in his development of Logo. In Logo, a turtle, which was controlled by student's programmed instructions, drew shapes on a computer screen. Pappert argued that when students created these shapes they 'were' the turtle and 'felt' the movements and turns in creating shapes. *TouchCounts* is similar in that it provides a new form of engagement where number is understood in multiple visual, audible, and gestural modalities among others.

Research with new technologies is still a new field as research is striving to keep up with new technology. There are frameworks that have been implemented but the overall number of studies is still very small. Since technology is changing so fast and new applications are being created everyday, different approaches are needed for new insights in learning mathematics, particularly with digital technology, since it is so new. In this study, the construct of rhythm is used as a unit of analysis when students engage with number in a grade one classroom, rhythm being a way to attend to what occurs during interaction rather than framing the human mastering the tool. Rhythm itself is a way to embrace the fusing of tool and user because it is a clearly material and easily identifiable result of an activity. While many frameworks identify the user of technology as the central figure in an interaction, this study adopts a new materialist approach that sees the user and the technology as being fused together, thus expanding the boundaries and consequently the potential of user and technology as one. Rhythm has been implemented in mathematics education (Roth, 2011; Radford et al., 2007). Moreover, rhythm can be seen as an aspect of learning number in how children learn to count. There is a temporal component in how children are introduced to the 'one', 'two', 'three'

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song. As an expression of interaction we are familiar with in music, rhythm shifts attention to the material. It is evident that rhythm aligns new forms of engagement with multi modal technology. This research report explores what rhythmic variations occur in different approaches to learning number, particularly with the use of the iPad app *TouchCounts*? [For information on TouchCounts see: http://www.touchcounts.ca/]

## Theoretical Framework

New materialist scholars (de Freitas & Sinclair, 2014; Barad, 2007) are challenging the duality and binary components of Cartesianism which separates mind and body. Consequently, one can approach the activity of a student working with technology as a material engagement and not rely on black boxed phenomenon such as thinking or mental construction. Critics of the immateriality of mathematics challenge the idea of what mathematics is and whether ideas can exist independent of physical materiality such as the body, the social collective, or even spoken words. de Freitas and Sinclair have developed a monist framework they term inclusive materialism that does not distinguish between digital tool and user thereby expanding the boundary of thinking subject as both technology and user as one material. This is important in this study because using a digital technology does not depend on mental contemplation and intention since that centralizes the 'thinking' in the student. de Freitas and Sinclair criticize representationalism because it assumes a mediation of knowledge that is based on the immaterial. According to Roth (2011), thinking is spontaneous and is not interrupted by constant mediation of interpretation and intent. The mediating aspect of representation is aligned with a computer model approach in which input is stored and operated on. Real life engagements do not seem to follow such a constantly interrupted flow of living forces. Roth argues that thinking is improvised in-the-now, particularly when engaged in a new activity.

New approaches in theory demand new considerations of methods. In this study, rhythm is taken to be the unit of analysis because it is its own unique phenomenon and yet something we are quite familiar with. Rhythm can be identified as a repeated action within a temporal consistency. It is not mechanical nor metronomic (Ingold, 2011) but has variance making it both organic and structured. It is fully material since what is seen and heard and felt contributes to our adoption of the construct. While rhythm is discounted as something extraneous or epiphenomenal, Ingold asserts that it is part of the development of knowledge and helps us understand learning. It is a significant part of the in-the-moment. However, it is also develops familiarity with patterns. Thus, it can be evaluated at the present time and it can also be used to predict what is to come.

It is the form of rhythm and how it aligns with the form of mathematics that makes it so significant. Rhythm provides evidence of the structuring of a human engagement with a mathematical idea. For example, ordinal numbers can be counted, rhythmically as 1, 2, 3. In that counting there is form, a structure of consistent beat and of always being able to add 1. These forms fuse together in practice, the rhythm emerging from their fusing so that the rhythm becomes a leader or guide to the structure. It takes over, and one becomes a part of its flow indicating that the social adoption of rhythm is where meaning begins and becomes.

Radford et al. (2007) describe rhythm as an indicator of generalizing. They position rhythm as a semiotic resource that is mobilized by students in their apprehending of a pattern and its subsequent generalization to convey a sense of generality. However, rhythm can be considered less as emanating from within students or as a constructed resource but more as an emerging engagement between student and tool. Rhythm need not necessarily be viewed as a choice or a personal expression but as a expression of material interaction. Radford et al. also draw on a notion of form in expressing rhythm. They describe two levels of rhythm when students express 'one, one, plus three', 'two, two, plus three' and 'three, three, plus three'. They describe the first rhythm as the verbal expression of the four beats of one, one, plus, three, where single syllable words one, one, plus, three, repeated in the

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next two expressions, indicate a level of rhythm in each single set of words. They refer as well to a rhythm of expression. That is, one, one plus three could be seen as beat one, two, two plus three as beat 2 and this beat 1, 2, 3 indicates a rhythm that can go on. While the first rhythm with words draws attention to repetition and to slight changes in that repetition, the second rhythm is about continuation and how each expression in its length, cadence and expression is the same, continuing with no end.

Roth (2011) has also explored rhythm, basing his critical approach on the concept of material body and metaphysical mind being distinct. He asserts that both are modalities of the flesh. His analysis is based not upon using new tools but upon focusing on people speaking and listening to each other. He argues that periodic features such as rhythm are produced and reproduced in interactions of verbal dialogues and that rhythm of speech is integral to the expression and recognition of knowing (p. 160). He identifies pauses in speech as important because they are part of speaking, the pauses giving temporal structure to the speech event. Roth further proposes that rhythmic phenomenon is not merely evident with individuals speaking or listening but that is also manifested collectively.

As a unit of analysis, rhythm, initiates a research practice that moves away from representationalism and pays attention to material force as a way to notice how and when it is expressed, how to account for changes, and how to highlight forms of knowing. In this study, rhythm is advocated as an emergence of form and structure when students engage in varying modalities of interacting. From this, further questions arise: What do we notice about the change in rhythms in an activity? How do rhythms begin, how do they end, and how do they connect to the meaning making practices in mathematics learning?

## Methods

The research took place in a multi cultural grade 1 classroom with 26 students in a French speaking school in Western Canada. Grade 1 was selected for observation because the curriculum centered on number sense, particularly on one to one correspondence, skip counting, numbers in depth as well as addition & subtraction to 20. It was on this foundation and curricular outline *TouchCounts* was introduced. The teacher had been teaching for 7 years and had not used *TouchCounts* before. *TouchCounts* was subsequently used in addition to some other techniques that the teacher was familiar with such as using hundred charts, Gattengo charts as well as using her hands.

Two researchers, including myself, visited the class approximately once a week for three months. We videotaped the classes which were taught both by the teacher and by one of the researchers. The videotaping focused at time on the whole class and at other times when students worked together in pairs or triplets. Notes were taken during the research by one of the researchers, noting relevant events. Videos were analyzed later, focusing upon rhythms of sound and movement.

## Data

Two episodes present different activities in which students are engaged. Not only is the organization of the activity different but the content is also different. The first sequence covering skip counting draws from a collective class activity using *TouchCounts*. The second is drawn from a group of three girls sharing an iPad using *TouchCounts* to create herds of five. What these two episodes contrast is the variations of rhythm that emerge in each scenario. While the rhythms need not be contrasted they do highlight how rhythms are unique in each context and how each rhythm has its own unique connection to mathematics.

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**Episode 1: Skip counting**

With *TouchCounts* set up on the front projector and students sitting on the floor, one of the researchers was teaching the class and introduced skip counting (Figure 1). *TouchCounts* supports skip counting in a very rhythmical way because one successively touches above the shelf, below the shelf, above the shelf, below the shelf and so on. In this way, rhythm is established not only in a spatial and temporal way both above and below but also hints toward continuation. The researcher modeled how to create even numbers on the shelf by saying 'one down here,' touching below the shelf, 'one up here,' touching about the shelf, and so on until 2, 4, 6, 8, 10 were on the shelf. She then asked the students to verbally repeat the numbers and the students said 'two,' 'four,' 'six,' 'eight,' 'ten' in a very consistent beat. While the students were uttering the numbers, the researcher, turning slightly to point at the screen, was moving her hand toward each number when it was said and then moving her hand back as if she were pulling away from *TouchCounts* (Figure 2). The researcher could have just moved her hand horizontally, pointing at each number as her hand moved, but instead seemed to let the movement on the iPad affect her movements in the air as she pointed. After resetting *TouchCounts*, the researcher called up a volunteer from the class to put 2, 4, 6, 8, 10 on the shelf. As a student was going up to the iPad, a girl beside the researcher side lifted one hand to mimic the iPad, used her other hand to point towards the tops of her fingers and said, "one on the top" and pointed lower down towards her hand, saying, "one on the bottom.". It did not seem like a question but a confirmation that she would be able to do it.

**Figure 1.** Children sitting on floor.

**Figure 2.** Pointing at numbers.

The student who came up to the iPad put the numbers on the shelf in the exact consistent beat that the researcher had put the numbers on. The researcher asked the students to state the numbers again and the same rhythm and pointing of the researcher was enacted. Two more students came up

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to put the even numbers on the shelf and followed steady, consistent, and in flow, in the exact rhythm. Each time the researcher asked the students to put one extra even number on the shelf. Each time the students read the numbers.

At one point a student was asked to point to the numbers as they were repeated. The pointing was as if she were using *TouchCounts*. She pointed and pulled away, pointed and pulled away, just like the researcher had done in the same timing as before.

When the fourth student was asked to put the even numbers on the shelf, the student put the number 2 in middle of the shelf. He matched the rhythm for his first two touches but then sped up for 3, 4, 5, 6, 7, 8 and then stopped because he was at the edge of the screen of the iPad. The class was quiet. After about 10 seconds, he fit 10 on by touching 9 below and 10 above in the same constant rhythm that had been established earlier. The researcher at this point indicated that he could put discs on the other side of the shelf. When moving to the left of the screen, he touched above the shelf and 11 landed on the shelf, the researcher asking if this was even. The student shook his arm in the air, back and forth, rhythmically, while the rest of the class, said no.

**Episode 2: Making 5s in *TouchCounts***

After a class activity took place in which students sat on the floor and the teacher performed 'friends of five', which entailed holding up a number of fingers. Raising two fingers, she then asked how many fingers on her other hand should be held up to make five. After this activity, students moved to work with *TouchCounts*. A group of three girls could be seen making 'friends of five' in this episode. The first girl touched the screen with two fingers, a herd of two being instantly created. She looked at her fingers, making three, and touched the screen creating a herd of three. Combining the two herds, a herd of 5 had been created. A second girl then moved the herd to the right and then moved her hands back towards her body. After adjusting her hair, she touched the screen with one finger, creating a herd of one and then touched with four fingers creating a herd of four, she then combined them and moved the 5 to the right of the screen under the first 5 (Figure 3).

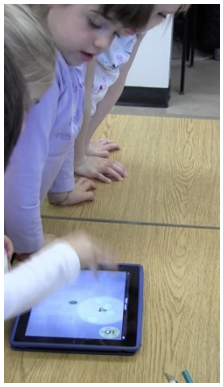

**Figure 3.** Second girl making herds.

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**Figure 4.** Third girl making herds.

These two girls established a rhythm. The timing of the movement was identical: touch once, look at fingers, touch again, combine, move to the side. The actions of the girls occurred in exact temporal alignment. The movement of their arms, the turning of the fingers, and the timing were all aligned thereby setting up a improvised but rhythmically negotiated approach to the activity. The third girl, however, did not match the rhythm of the previous two girls because she was interrupted. She touched the screen with two fingers and, as soon as she did that, the first girl moved her body toward the iPad, saying, 'You can't do the same as I did,' causing the third girl to not let go of the 'two' and just waited. An observing researcher attempting to prompt her with a question, asked, 'What can you add to two to make five?' She then touches three, combines the two numbers very slowly somewhat unsure of what may happen (Figure 4). The slowness is a new rhythm, possibly brought about by the interruption. As soon as a third girl created a five, the second girl from the previous turn-taking moved the five to the side and continued to repeat the same rhythm as before with the same timing and the same pattern of looking at her fingers.

## Discussion

In the first episode, the mathematics was based upon skip counting. The rhythms that emerged were consistent among the researcher and the students. The consistent gestures that appeared, both in the touching of *TouchCounts* and the pointing at the numbers on the projector screen, remained within a very specific rhythmic pattern. Almost all the touching and pointing approximated the beat of the second hand on a clock. This rhythm addresses the notion of the social collective and how both the technology and social engagement with the technology had remained similar throughout the whole activity. It could be assumed that each student who participated in touching *TouchCounts* was mimicking what the researcher had done but this would imply that a mental intention is present as opposed to the improvisation alluded to by Roth (2011). Furthermore, if we see the student using technology to accomplish a goal, we lose sight of the central thinker in the interaction. While it might seem that the student is placing the numbers on the shelf in a very controlled way, this puts all important activity in the mind of the student. However, by seeing rhythm as a result of social becoming and as evidence of material engagement of a student-digital tool, we begin to see the importance of how rhythm carries students along. Rhythm seems to convey that a certain collectivity precedes knowledge.

As a researcher, I differentiate two different rhythms in this activity like Radford et al. (2007). The constant timing and movement of the above, below, above, below touching was a rhythm of repetition. As previously noted, this is important because it identifies a connection between social rhythm and personal rhythms. There is, however, also the unit of repetition that repeats which exists when the researcher, then one student after another, all express the same repetitive rhythm which has become a rhythm of continuity. This higher level rhythm gives a structure to the idea that the skip

counting can continue onward. Each student who was observed was requested to put one more even number on the shelf. Consequently, there were slight differences, not found either in the constant rhythm of touching the screen nor in their movements in how they touched the screen. The last boy who did not fulfill the task did not follow the rhythm of the previous students. He sped up, he stopped, and then moved to the left side of the screen of the iPad. This is evidence that there is room for variation of engagement leading to different expression of rhythm, thus highlighting the significant of the same rhythm set by the researcher and three students who followed her.

In the pointing at the numbers on the shelf, both the researcher and the student pointed in a unique way, one that had been established in using *TouchCounts*. Here we see how rhythm establishes itself in the activity. For the fourth student, spacing became important when we saw rhythm develop or breakdown. The student's rhythm had been interrupted so that a new negotiation with the technology was needed. However, the previous rhythm did not seem to want to provide any more time and so he touched with 11 and was incorrect.

In the second episode, the rhythm established by the first two girls indicated an alignment of meaning making. The fingers, making the 2, then the 3, then combining the 2 and the 3 and then moving 5 to the side, created a form of engagement that is mathematical. Although moving 5 to the side could be argued to be extraneous, the movement of the 5 as an object was an action that was not present in whole class activities. However, this movement in the rhythm, as a repeated step and within a temporal framing, was afforded by *TouchCounts* so that in moving the five as a step in the activity, the girls legitimized the herd of 5 as a mathematical object, demanding its own gesture and it own space. There is an important aspect here of how rhythm, improvised as it was, creates an opportunity of understanding the mathematical symbol as being more than something to look at or say its name. The rhythm creates an opportunity for the object 5 to be touched and moved, just as any material object could be. While this may happen without rhythm, one still wants to know how this could occur. Without being told by a teacher and without a reason to touch 5 and move it, one wonders if an activity could be thought up to support this new form of engagement. However, in the social negotiation of creating 5s, there was a need for space, and there is a strong argument in the rhythm of 2, 3, combine, move, and 1, 4, combine, move, that the repetition and the exact temporality plays a part in the creation of number beyond sight and sound.

The result for all three girls was the same. Each created a herd of five. However, the third girl had a unique rhythm after having been interrupted. After the interruption, each movement was unique. She touched the screen quickly but kept her hand on the screen, later combining 2 and 3 very slowly. Her rhythm did not match the previous rhythms but became an attempt to renew a form of engagement. The important point is that each student ended up with a herd of five but the differences in how the first two were achieved, compared with the third creation, draws attention to process as opposed to product. If rhythm is the process of engagement, the third girl had a different 'understanding' of combining 2 and 3 than the first two girls.

## Conclusion

Mathematics can be seen as a set of propositions that can be acquired, stored and applied to different situations. This supports the idea of representation which raises the question as to whether this approach to learning and knowing is too dependent on interpretative mediation. Life and movement, according to critics of representationalism, do not reflect such stop-and-reflect kinds of practices. Inclusive materialism, a new materialism established in mathematics education, privileges material interactions as knowing. With new digital technologies, methods that align with theoretical materialist approaches are needed to understand mathematical classroom practices. In the present study, rhythm was formulated as a correlative between new technologies and the social and the personal.

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In early education, counting is very much rooted in a rhythmic expression. However, new technologies support new rhythms. More specifically, the use of TouchCounts, both in a whole class activity and in a smaller group, enables the creation of a rhythm which provides an opportunity to experience mathematics within the context of an improvised and unique structure. In conformity with inclusive materialism, rhythm as an unfolding emergence is an expression of living forces and materials. In this study, we have seen TouchCounts provide new ways of engaging with skip counting. A gestural approach attends students both to the skip counting pattern and to the numbers that are skipped as well as to the temporal aspect of developing a sense of sequence. In adding 2 and 3, a new engagement with the number 5 emerges, not solely because of the affordances of the technology but because of the emergent improvised rhythms that create a need for such an interaction. Rhythm can help anticipate what is to come. Teachers may use emergent rhythms as a way of understanding collectivity or individuality, noticing as well how the in-the-now rhythm structures affect the rhythm that is to come.

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