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Dimensions to Be Considered in Teaching, Learning and Research with Mobile Devices with Touchscreen[1]

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ABSTRACT

Mobile devices with touchscreen – smartphone or tablet – constitute a physical extension of the body, and the communication that such interfaces promote has come to be understood as displacement. Considering specificities such as mobility, convergence and ubiquity, this article proposes six dimensions (contemporaneity, socio-technical, neurocognitive, perceptive-affective, discursive-communicative, political-pedagogical) that can be considered in teaching, learning or research in Science, Technology, Engineering and Mathematics (STEM). Dimensions are delimited with the *features* of contemporaneity.

Keywords: Embodied cognition. Touchscreen. Smartphone. Tablet.

Dimensões a Considerar no Ensino, Aprendizagem e Pesquisa com Dispositivos Móveis com Toques em Tela

RESUMO

Dispositivos móveis com toques em tela – *smartphone* ou *tablet* – constituem uma extensão física do corpo, e a comunicação que tais interfaces promovem passa a ser entendida como deslocamento. Considerando especificidades como mobilidade, convergência e ubiquidade, o artigo propõe seis dimensões (contemporaneidade, sócio-técnica, neuro-cognitiva, perceptivo-afetiva, discursivo-comunicativa, político-pedagógica) que podem ser consideradas em processos de ensino, de aprendizagem ou de pesquisa em Ciência, Tecnologia, Engenharia e Matemática (STEM). As dimensões são delimitadas com *traços* da contemporaneidade.

Palavras-chave: Cognição corporificada. Toques em tela. Smartphone. Tablet.

INTRODUCTION

The history of humankind is constantly imbued and remodeled by the creation, use, appropriation and reconfiguring of technologies. We are continuously creating

[1] This article is a revised and amplified version of Bairral (2018).

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technologies, and these technologies, synergistically, keep re-dimensioning us. Since their birth, little thinking humans come into being through languages, machines, systems of representation that structure their experience (Lévy, 1993, p.161).

The emergence of the Internet and the increasing progress of its possibilities have promoted an unprecedented expansion of borders for human cognition and communication. In the encounter among mathematics, physics, biology, psychology, philosophy, anthropology, sociology, education, communication and arts, neurosciences have come to fascinate people with the possibility to understand the mechanisms of emotions, thoughts and actions, illnesses and madness, learning, oblivion, dreams and imagination, phenomena that define and constitute us (Ribeiro, 2013). These, among others, are subjects of concern and reshaping all along with our history.

Our minds, bodies and physical environment work in constant synergy (Moore-Russo; Viglietti, 2014). In the physical spaces we move through, we deal with technological, cognitive, cultural resources. Among those resources, devices[2] such as smartphones or tablets provide, together with their mobility, (which they share with other artefacts, like cordless telephones, for instance), a convergence of media in a single device, and ubiquity (the possibility to surf different spaces thanks to their connectivity). In terms of mobility, we can think of actual mobility or virtual mobility (Lemos, 2009), and we may as well connect our existence to movement rather than following Cartesian logic which would connect our existence to the basic assumption of rational thought.

As they are extensions of our bodies, Mobile Devices with Touchscreen (MDwT) run through us, and we run through them. With them, we consciously or unconsciously build our ways of being, of moving, and not necessarily within our physical bodily dimension. We come to be bodies with technologies and technologies with bodies (Ihde, 2002).

In this article,[3] I illustrate six dimensions[4] (contemporaneity, socio-technology, neurocognitive, perceptive-affective, discourse-communicative, political-pedagogical) that can be considered when MDwT particularly, smartphone or tablet, come into play in teaching, learning or research in STEM. These dimensions are not isolated or mutually exclusive fields. The reflections woven here are the beats and strokes of a mathematics educator researcher.[5]

[2] Words such as device, resource, apparatus, interface, tool, machine and mechanism have similar meanings through this text.

[3] From a research project financed by CNPq.

[4] In this article I use the word Dimension in a broad sense akin to “realm”, and not with the more specific sense, such as length, width, etc.).

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CONTEMPORANEITY DIMENSION: APPARATUS, MOBILITY AND TERRITORIALITY

Nowadays, when we speak about mobile technology, we usually limit our thoughts to cell phones or tablets. However, using devices to reach further is not a specific feature of our times: remember that we wear glasses, use pens and didactic material such as a compass, a table of logarithms or a protractor, for instance: they are all mobile technologies. Notwithstanding their specificities, there is a singularity about mobility, a notion that is articulated to the ideas of borders and territory.

We are contemporary subjects (Agamben, 2009) . This is a fact that implies mobility: We belong to our time, but we keep a distance. Moreover, mobility does not exist without stillness, immobility. They each imply the existence of the other (Lemos, 2009). Mobility is contemporary, as it is a recurrent human concern, a reflection on a time when the present cannot be hegemonic. So contemporary is not necessarily what is new or current. Thinking about what is contemporary is to think of subjects who travel through different moments in time, without necessarily locating the present as a determinant for their actions. Contemporary subjects keep their gaze fixed on their time to grasp not its lights, but its darkness (Agamben, 2009).

The idea of apparatus, or device, is not new either, although it often seems to be. Agamben (2009) considers, drawing from Foucault's power relations, that a device is any heterogeneous set (linguistic or non-linguistic) that comes into our lives and transforms the relations and the discourses of living beings. Time (not necessarily the physical time of the clock) and politics are examples of devices. There is a particular type of device that issues from the military discourse. A device that is technological in nature will analyze how the pieces in a mechanism are arranged within a machine, or the mechanism itself, for example. Then, a reflection on what a device is, how it enters and interferes in our lives and our ways of thinking would be a reflection about some darknesses on our way.

The novelty of a mobile device brings light, but it also generates shadows, silhouetting us in different times and spaces which are unique and complex. The notions of border(s) and territory(ies) come hinged on the feature of mobility. Both territory and borders are concerns that traverse our history (Augé, 2010). The idea of border, frontier, is far from recent. Let us turn to think about what mobility means in our time without forgetting the past, as we are also able to look towards the future.

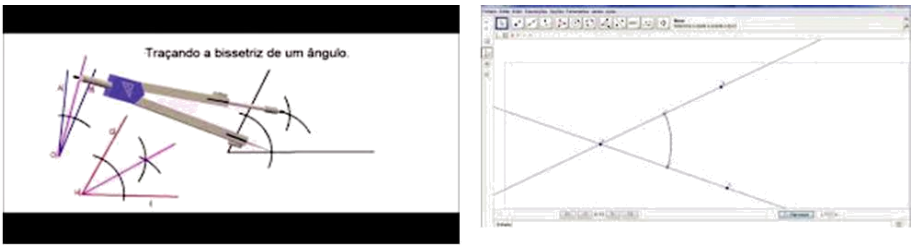

Figure 1. Building a bisector, (a) with a compass, (b) with GeoGebra (Google *pictures*)[6].

Different devices contribute differently to our learning. As we interact with them, we follow procedures or concepts already existing, or we generate others. For example, although the compass and the protractor have been part of the student life of some of us, we currently have other ways to do constructs and measurements of angles and other mathematic objects. One of them is a Digital Geometry Environment (DGE) called GeoGebra. Actually, the great challenge is to produce new mathematical concepts and strategies of thinking. However, yes, it is possible! In fact, operations with angle measurements using degrees, minutes and seconds should not belong in the school curricula any more.

A DGE, GeoGebra for instance, provides those measurements and does not use only whole values for the angles. Therefore, performing the operations does not have to figure in the planning, but measurement and comparison will certainly be reconfigured. Instead of calculating, what we can do is interpret and analyse various measurements. In addition, building only a bisector with GeoGebra, as shown in Figure 1b,[7] is taking far too little advantage in exploring this resource, which allows the user to build and analyze different constructs, concepts, properties, and establish relations.

The compass, although it can be constantly open and closed, is a device that lacks mobility. A DGE, used on a desktop, despite constructions with several movements, does not possess mobility either. However, a DGE used in a smartphone has mobility. In the first two cases, the user needs to go to each of the devices and provoke their mobility by taking them. In the latter, the device is potentially endowed with mobility, although it can temporarily remain still. Let us delve in the idea of mobility (and motionlessness).

According to Lemos (2009), mobility can be seen in its physical or virtual (informational) aspect. This browsing, this temporary rupture of the physical dimension that is mobility, affects even our perception. By way of illustration: We have come to an auditorium to listen to a lecture, we sit down, we speak with the person next to us, or each person keeps minding their own business. We are in a borderline area that allows

[6] https://www.google.com/search?biw=1267&bih=613&tbm=isch&sa=1&ei=tNVBW_itA7SQmgX0y5GIDQ&q=construcao+de+bissetriz+com+geogebra&oq=construcao+de+bissetriz+com+geogebra&gs_l=img.3...53759.55097.0.56359.8.8.0.0.0.0.158.447.6j1.7.0....0...1c.1.64.img..1.0.0....0.zjNwJK5PpWU#imgrc=_ Access: Jul. 8, 2018

[7] The figure illustrates the beginning of the construction of the angle.

us to either detach ourselves or wander in unanticipated topics of conversation with unexpected people.

Thinking of (de)territorialization is thinking about the tearing down of borders. We are living at the same time as we are navigating through different universes. We feel free, but we can also feel caught up, imprisoned. According to Augé (2010), space, the territorial issue, is paradoxical: with the Internet we are free, but we are being regulated. This paradox is not an exclusive feature of our present time. It belongs to the contemporaneity dimension, although of course, it appears differently outlined at different moments in time. As Augé (2010) prompts, it is necessary to rethink the frontier, that reality which is endlessly rejected and persistently restated under hardened forms that work as prohibitions and provoke exclusions.

Reflecting upon the borders, when you have distant close ones, close distant ones, is trying to understand the contradictions that affect contemporary history, as borders do not undo themselves, they readjust themselves, (Augé, 2010). In that regard, mobility will be enriched in the present time with ubiquity (Couto; Porto; Santos, 2016). We all wish for powerful mobility, physical or virtual. Now, would it be the same without ubiquity, the possibility to be present everywhere at the same time? In relation to this, we need to see the transformations of IT.

SOCIAL-TECHNICAL DIMENSION: UBIQUITY, CONVERGENCE, CONNECTIVITY

The progress in information and communication technologies has changed the way to be in the world of the living and, consequently, to learn, to teach and to do research. Social-technology arises with technology. Thanks to it, connectivity allows us to navigate through places never imagined before. However, just as it allows us to fly, it imprisons us. It allows us to participate in different collectives, but it abducts us in a world of supposed happiness and constant pleasure. Based on Augé (2010), it is worth noting the distancing and nearing among people, objects or places; empowering and weakening of interpersonal relations; varied possibilities of obtaining information and the little critical analysis done of it are some of the paradoxes, among others, that mobile devices bring to our times.

Lévy (1996) also reminds us that roads and cars, currents and ships, sails and winds either join or separate cultures, and affect the networks' shapes and densities. Intelligence and cognition are the result of complex networks where a large number of human, biological and technical actors interact. He coins the term "cognitive ecology", to refer to the study of technical and collective dimensions of cognition (Lévy, 1993). With their virtual mobility (Lemos, 2009), MDwT can broaden our displacement, connecting and re-signifying possibilities, both individual and collective.

Nowadays, being connected implies the possibility to wander through (un)known places. We have difficulty to imagine our cell phone without its connection to the Internet. It seems that something is missing in our blood current (and something *is* actually

missing!). In the same way that the notions of device or mobility run through our history, we have connectivity. The forms of connectivity in our time are re-dimensioned, and we can traverse a variety of spaces, observe strange behaviors, watch different cultures, talk to strangers and acquaintances. What thoughts about wandering and communicating can arise from the pictures in Figure 2?

Figure 2. (a) Reading on a train, (b) family gathering (Google *pictures*).

Do they affect us, transport us, disturb us, frighten us? You! Reader, have you found yourself in a similar situation? Do both images intrigue you, or just the second one? In fact, we sometimes adopt a nostalgic attitude, when we say we sit at a table for a meal and do not talk to each other. We are interacting through our cell phones! Keeping aside the particularities of each historical moment, would those general concerns belong only to the present time? With the advent of television, was there a change in the way people communicated and interacted? Being contemporary subjects, we cannot fix our gaze on one reality only, nor consider technology as a final solution to our problems, particularly the ones referring to education.

Convergence and ubiquity arise thanks to the progress in information and communication technologies.[8] Imbued in the techniques of convergence and ubiquity, both the individual and the collective move dialectically. An application, which has been designed for individual use, is constantly being remodelled, based on the use that its owner submits it to. Therefore, the interaction that will be helping this reconfiguration is not only of the human individual with the machine, but of the human with other humans, and not necessarily on the device itself, but on the different spaces frequented by the individuals. Somehow, our subjectivity travels between the individual and the collective, and the borders are flimsy.

Our smartphone has a series of functions. We take a photograph, we can edit it, share it, and use it in the production of different contents. As a matter of fact, we seldom

[8] Some innovating research in mathematics education, for example, in Brazil, with augmented reality (Maurício Rosa, UFRGS), with sensors attached to graphing calculators (Janete Bolite Frant, UFRJ; Nilce Scheffer, UFFS), with videos produced by students or teachers (Marcelo Borba, UNESP-Rio Claro/SP), or, in Finland, with the use of gaze trackers (Markku Hannula, Univ. Helsinki), would not be possible without updated IT.

use our telephone to make a call at all. Convergence and ubiquity reconfigure the initial use of the cell phone. In addition, with the MDwT, we have passed from the logic of *download* (from sitting in front of the computer, turning it on, connecting it through a cable, looking for content and downloading it), to upload, where contents arrive directly to us through invitations (SMS, timeline, etc.) in different formats. We have moved from a communicative logic that is centralised and directed (one for all) to a dynamic logic where the device works from its owner's use. Besides the configuration of the device based on its owner's requirements, the subject acquires an important role in the production of various contents.

The MDwT are also forms of memory, our expanded memory. It is a technical modification that has triggered new analogies and classifications of other practical, social and cognitive worlds (Lévy, 1993). In a DGE, I explore, interact, learn, individually and collectively,[9] physically or virtually.[10] The device alters me, and I alter it. Imagine what could be said of my feelings, when learning with those interfaces?

PERCEPTIVE-AFFECTIVE DIMENSION: AFFECTION, PERCEPTION

The perceptive-affective dimension features affection, feelings and seduction as some of its triggering characteristics. It covers affection in the sense of being affected, being moved (Skliar, 2014), emotional feelings, perceptions (Damásio, 2011), images and awareness (Damásio, 2018).

The way in which we take possession of technologies is in constant interaction with the environment. In other words, technology has an effect on the environment, which in turn reacts with, or over technology (Maturana; Varela, 2001). The smartphone being an expansive technology (Bolite Frant; Castro, 2009), non-restorative of the physical aspect of our bodies, we come to do, with this device, things we would not do without it.

Touching, as a technology, is not recent, but is our perception the same when we touch the screen at the ATM machine or an *ultra book* as when we touch our cell phones or tablets? In a similar way, is our sensorial perception different when we click with a mouse than when we deal with an MDwT? Using a corded mouse may not be the same as using a wireless one. Each form of handling promotes different mappings in our brain, which can be related to sensitivity aspects, spatial features, (dis)continuity in handling, through (in)direct contact (Bairral, 2017).

In this dimension, then, the singularity – of mobility with touching – must be taken into account, because our brain keeps adjusting to what is being offered to it (Damásio,

[9] Access http://www.gepeticem.ufrrj.br/portal/materiais-curriculares/pontos-notaveis-de-um-triangulo/ and see, among other contents in a DGE, another way to connect and learn. Access: Jul. 27, 2018.

[10] Visit *online* the Museum of Natural History and Scientific Instrumentation of the University of Modena and Reggio Emilia and discover other possibilities to learn by dealing with compasses. http://archivioweb.unimore.it/theatrum/ macchine/_00lab.htm Acess: Jul. 27, 2018.

2010), and interfaces with touching on the screen are bringing new configurations to the brain. Our body must be seen as the mind that understands our thinking, our feeling and our acting (Damásio, 2004). Now, a distinction must be made between feeling and emotion.

Emotions are actions accompanied by ideas and specific ways of thinking. Emotional feelings are mainly perceptions of what our bodies do during this time lapse (Damásio, 2011). Emotions are complex *action*[11] programs, automated to a great extent, generated by evolution. Actions are complemented by a cognitive program that includes specific ideas and cognition mode, but the world of emotions is, above all, made of actions executed with our bodies, from facial expressions and posturing to changes in our viscera and internal milieu (Damásio, 2011). On the other hand, Damásio stresses, emotional feelings are the *perceptions* composed of what is going on in our bodies and our minds when an emotion is running its course.

Feelings are images of actions regarding the body, and not the actions themselves; the world of feelings is made of perceptions performed on brain maps (Damásio, 2011). As the failure to learn mathematics, a negative emotion, leads to evoking thoughts on negative facts. Emotional fire is the energy with which we constantly chase ideas to be reached (Mora, 2017). Our joy and our sadness alter the state of our impulses and motivations, instantly changing the mixture of our appetites and desires (Damásio, 2011).

NEUROCOGNITIVE DIMENSION: ENVIRONMENT, LANGUAGES, IMAGES

Our organisms are formed by a brain-body set which always interacts with its environment as a whole (Damásio, 1996). If the body and the brain interact intensely between them, the organism that they constitute interacts in a similarly intense way with the surrounding environment, and their relations are measured by the movement of the organism and the sensorial equipment.

Anatomic changes in our brain take place all along our lives, fostering capacities, abilities and the personality itself that an individual forges and develops (Mora, 2017). Our minds, our bodies and the physical environment work in a constant synergy (Moore-Russo; Viglietti, 2014). Physical space (like the classroom) includes different apparatus or systems (technological, cognitive, cultural, etc.) with which we deal. Their entrance into our life (and body) alters our way of being in the world (Idhe, 2002). Our environment also reconfigures itself.

To illustrate this, let us think of residential houses which used to boast a telephone, a few years back. There was a design, a layout. There was a special place for the telephone, a paper pad, an address book. Sometimes there was a chair to sit on while we talked. Because, ah! Yes, the telephone was for talking, even if phone calls were sometimes

[11] In italics in the original.

expensive! With wireless telephones, that physical setting was reconfigured, and the speaker could move along the telephone call. The place to talk on the phone ceased to be physically defined the way it had used to be.

With recorded voicemail messages, not even the physical presence of the receiver was needed. Then cell phones arrived, with all the reconfiguring they implied (touching, applications, inset social nets, etc.) and what happened? One of the reconfigurations is the widening scope of our physical and informational displacements (Lemos, 2009). Let us leave our homes and the detachments from them and have a look at our bodies and how they have been the objects of analysis in research.

In the field of embodied cognition in mathematics education research, the relation body-whole was given priority, given the particularities of the available devices at the time (sensors inset in graphing calculators) and the very nature of the study (Borba; Scheffer, 2004). Nowadays, with the emergence of new interfaces, we can also analyse, by viewing on the screen, parts of our bodies through projected views (Hannula, 2018), or map the touching on the screen (Assis, Henrique, & Bairral, 2018).

Controlling manipulations on screen, on which our research group[12] based some recent study, represents a new form of language manifestation and come to integrate our embodied cognition (Bairral, 2017). Although the possibility to touch the screen is not recent, the mobility and the type of sensitivity and performance offered by some devices are quite new and have made an impression on us. The changes that take part in a creative process generate innovation (Mora, 2017) and touchscreen on mobile devices are not cognitively the same as mouse clicks (Arzarello, Bairral, & Dané, 2014).

Some touches that we make on the screen can be related to gestures (make a zoom, simple or double touch, flick, for instance). Others are not limited to specific gestures (McNeill, 1995), and they open up a whole new agenda for research about manipulation, either originating from it or directly operating on it. They constitute the expression or simulation of some mental process. Although they belong to a realm of the language that materialises in images (not necessarily sounds), these manifestations do not restrict themselves to gestures or kinetic expressions. Gestures, touches and other ways of manipulation *on*, *with* or *from* the screen express thought and they must be considered as one integrated and dialectic system (McNeill, 2002).

Touching on the screen generates a whole net of different movements, combining themselves, often forming a multifaceted symbolic system (Bairral, 2017). Ubiquity and mobility in a tablet or smartphone imply a better understanding and interaction subject-environment and, in this sense, the expansive dimension of technology in the process of conceptual holding is still more in demand. Damásio's sound statement is welcome here:

> [...] a concept is a collection of simultaneous reconstructions of sensory and motor representations that have a high probability of being triggered by the same

[12] Available at: www.gepeticem.ufrrj.br

> non-verbal or verbal stimulus and whose occurrence: (a) permits the natural assignment of a perceived or recalled entity to a variety of taxonomic classes to which it may belong, given the features and dimensions embodied in the coevoked representations; (b) permits a verbal narrative of the features and dimensions of the class in such a way that appropriate definitions of the entity can be generated (1989, p.24-25)

As the brain is the captive audience in our body, there is a flux of images (visual, auditory, olfactory, gustatory, somato-sensitive) which is made when we mobilise objects from outside the brain towards its interior and, when we reconstruct objects from memory, from inside towards the outside. This flux, which can be represented pictorially, composed also with words and abstract symbols (not represented with simple images), can be called thought (Damásio, 2005). In the case of mathematical thinking, we need to consider that a concurrence of gesture + speech + construction-on-the-screen + touches + pictorial-register + movement-with-the-device + movement-with-the-body compose, with the same relevance, the linguistic-cognitive spectre of the subject (Bairral, 2017). Although manifestations through images are often difficult to be captured or analysed synchronically, we cannot value only written registers.

Through this flux of images, our brain builds various mappings, and interaction becomes increasingly crucial in our learning process. Skliar (2014) reminds us that our function as educators is to talk to strangers. He stresses the fact that every conversation is a permanent tension between different ways of thinking and of thinking oneself, of listening and listening to oneself. There are dissonances, misunderstandings, misconstructions. Are situations such as those challenging only nowadays? Or are they increased, maybe, by the speed with which information and communication technologies have altered things and altered ourselves? In that case, as we are affected and given the need to talk in various ways with strangers, it is essential to consider the communicative-discursive dimension.

DISCURSIVE-COMMUNICATIVE DIMENSION: CONTEXT, DISPLACEMENTS

When we think about the contemporary, about mobility, about travelling within or across or through territories, connecting or disconnecting with the past or the future, we are led to think about interacting. Interacting (whether subject–subject or subject–device, whether subject-other or subject-other-self, or other-self) is indispensable in human development. This leads to our thinking about discourse.

Discourse is basically interactive and takes place through language, but it cannot be the object of a purely linguistic approach (Maingueneau, 2000). Besides the use of language, (oral, written, pictorial, kinesthetic, gestural, etc.), discourse involves the communication of beliefs and interaction in situations that are social in nature (van Dijk, 2000). As a matter of fact, discourse comprises a whole set of systematically-organised modes of articulation of institutions and social groupings, providing descriptions, rules,

permissions and prohibitions of social and individual actions (Kress, 1990). For instance, in this paper, which belongs to the discourse of education, we are dealing within a space that has explicit and implicit rules. If I use real estate publicity as an example, I do not expect my readers to believe that I am dealing with real estate or that I am advertising goods or services. So, communicative practices are constantly interpreted and negotiated within a discursive context. In turn, discourses do not exist in isolation but within a larger system of sometimes conflicting, contradictory, or merely different discourses. As you are reading this, a communicative action is taking place. Nevertheless, there is not necessarily any direct interaction between me (the author) and you (the reader). Every interaction is a communicative act, but not every communication triggers an interactive process. Again, not directly: Discourse goes beyond direct interaction.

A discourse, although it is often delivered as individuals' free creation, is produced and interpreted in specific contexts. Although it is hinged together with the culture in which it is being (re)produced, it is not a neutral communicative act.

The photographs below would have a different impact on the viewer depending on whether they show only what is in Figure 3 (a), or together with what is shown in Figure 3 (b). When I show the picture in Figure 3 (a) and I ask people what they see, the answer is numbers, calendar dates, the month of April. Following this exchange, when I show the second picture, which I took in Salvador (Bahia, Brazil), there are smiles and expressions of surprise. Even in Bahia, where this ad, which is a manifestation of real estate publicity discourse, is supposedly familiar, reactions have been similar.

Figure 3. (a) Only the numbers, (b) fractions in a real estate publicity context.

In figure 3 the fourths (fractions direct us to mathematics) are used to write the number of rooms in an apartment (real estate publicity context). So learning is influenced by the context in which it is produced. This example is also useful to the discussion on the universality of mathematics learning. In other words, we have to bring into perspective the thought that mathematics must be learnt in the same way by everybody. Mathematics has the particularities as a language with its own signs. The presence of such signs leads us to consider that we are reading something serious and objective. However, let us look

at Figure 4, below. Even if we know that "*Apartement à louer*" means "for rent" and we know the numbers in the following figures, what do these ads mean? What is the meaning of fractions 3 ½ and 4 ½?

Figure 4. Photos showing ads of apartments for rent in Montreal, Canada.

In Figure 4, ½ means a bathroom. That is a 3½ apartment has three rooms (usually a kitchen, a living room, a bedroom and a bathroom; and 4½ is an apartment with four rooms (a kitchen, a living room and two bedrooms) and a bathroom. The context has changed, the way to produce knowledge has changed, consequently. I am stressing the importance to analyse each situation and its influence in the way to conceptualise and define mathematically.

Figures 3 and 4 also can serve to explore the idea of communication as displacement (Lemos, 2009). They can allow us to convey, even if only punctually, momentarily, to the context in which the message was produced, so that we can attribute some meaning and react to it, (showing surprise, conformity, etc.). As it is a system of representation,[13] discourse also reconfigures our experience, our way of thinking. In this process we consume, add, produce and distribute contents in different formats, spaces and times.

However, there is more than the context that situates discourse. Society, institutions and other larger groupings also play their role, gaining and losing power and areas of influence. They do so through the human communication of individuals and their devices.

> Given that each discourse tends towards the colonisation of larger areas, there are dynamic relations between these which ensure continuous shifts and movement, progression or withdrawal. (Kress, 1990, p.7)

So it happens that the discourse of publicity uses the language, signs and resources of mathematics, music or poetry for the purpose of turning reality into a big stock of items to be sold and acquired. As we are immersed in the discourse of publicity, we tend to view every interaction as part of some profit-making business, and we tend to

[13] Consider the various forms of register (pictorial, graph, numeric, table, algebraic, etc.) generated statically or dynamically, expressed in isolation or articulated with other forms.

consider this as natural. The effects of discourse do not limit themselves to responses in language. So, for example, the systematic overvaluing of the business of education as a private (and privately successful) enterprise at the expense of a systematic undervaluing of a public schooling system oriented towards dignified responsible citizens have had devastating long term effects on the process of educating a nation into the pleasures of learning and living together (political dimension) instead of competing for consuming or merely getting a job.

In fact, the discursive dimension is closely related to the political-pedagogical dimension, so let me bring in Carlos Skliar (2014) again, by emphasising that we should pay closer attention to the institutional marks with which we intend to regulate, manage and also destroy educational talk. We are composing the strategic action of our profession, which is imbued with a pedagogic-political seal.

POLITICAL-PEDAGOGICAL DIMENSION

Thinking about the dimensions referred to above and reflecting over our role as educators is paramount. If we understand by politics the concerns and management of what belongs to the community, what is public, then we have to agree with Paulo Freire that educating is a political act (Freire, 1997), and one of the strategies to actualise it is through the curriculum. In a globalised world, a Curriculum must consider cultural aspects (of schools and regions) as well as personal (of teachers and students), and value the local cultural characteristics, which can never be seen as minor aspects in an educational process.

There is no sense in a universal curriculum. Nevertheless, just as a student in the city of Sao Paulo can get to know what happens (history, architecture, language, ways of life, economics, means of transport, or ways to promote the sales of real estate) in a small provincial town, other aspects can also be important. The challenge for an effective curriculum is to account for the cultural, discursive, cognitive exchange and interaction among learners. With this in mind, mobile technologies can be beneficial. Why do we do research? Why do we teach? Why do we become teachers? Why do we train educators? It is up to us, as trainers, as researchers, to keep claiming for qualitative changes in the educational process, because there is a strong current undermining social gains and achievements, like the recent *Base Nacional Comum Curricular* (BNCC, Common National Curricular Base)[14] or the new Secondary School Reform (*Reforma do Ensino Médio*) in Brazil.[15] Besides not providing teachers better salaries and equipping schools adequately in order to contemplate the new demands and students' areas of interest, weakening teachers' training and disregarding education in the Humanities, this reform is basically patterned on a list of prescribed objectives that limit themselves to large-

[14] http://novoensinomedio.mec.gov.br/?fbclid=IwAR2F8SCzf26Mp60Zgoh1slLYXtL6uwoOy4hLOKdl7RSKGwu05HiDNkF8kdw#!/saiba-mais Access: Feb. 9, 2019

[15] http://novoensinomedio.mec.gov.br/?fbclid=IwAR2F8SCzf26Mp60Zgoh1slLYXtL6uwoOy4hLOKdl7RSKGwu05HiDNkF8kdw#!/pagina-inicial Access: Feb. 9, 2019

scale evaluations systems. In fact, what we have seen is the government absent from its obligations and opening spaces for private initiative.

A curriculum should not be a common homogenising action, or, even less, a minimum set of competencies previously determined by some agents who are alien to educational institutions. As we live, we are constantly innovating, and there is no doubt that mobile digital technologies can contribute to qualitative changes in pedagogical interventions, in curricula and learning. Therefore, a curriculum is an educational strategy that is political. School and teachers produce curricular politics in their practice (Ball, Maguire, & Braun, 2016).

A curriculum is a dynamic affair. It is fed back by (trans)formations and (re) significations effectively built by the ways in which the stakeholders produce meanings for the reading of the prescribed document. The mathematics classroom should foster communication following the guidelines of the interactions, negotiations and (re)construction of meanings that belong to the users. The guarantee of success of a curricular development cannot be found in legal decisions, however important they might be. Legal decisions have no decisive role in prescribing an objectively mapped success (Bairral & Assis, 2018).

As politics are made by and for teachers, they are actors and subjects, subjects and objects of policies and politics (Ball et al., 2016). In the case of operating or measuring angles, as discussed in Figure 1, the decision to apply a series of procedures (it can be cognitively deficient), with or without relation to involved concepts will be up to the teacher, preferentially, and to the teaching body in a school. Alternatively, they can propose other situations in which the students can compare, estimate, identify and analyse invariant geometric objects (angles, sides, shape, area, properties etc.) in situations involving various concepts and properties, with a greater reasoning potential (Stein & Smith, 1998).

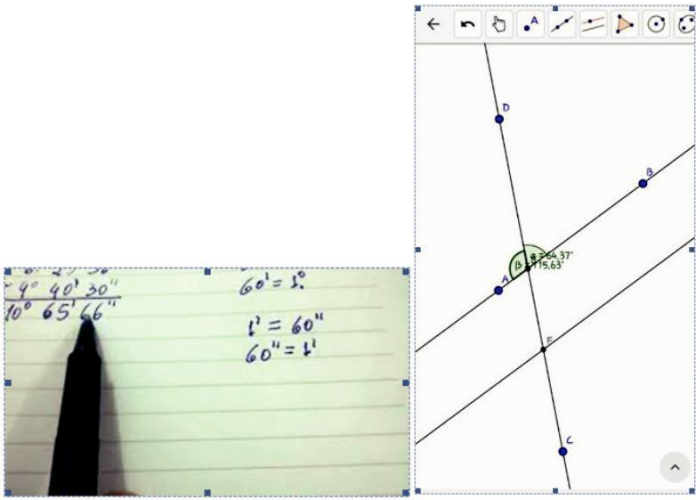

Figure 5. Student (a) adding up angles using pencil and paper; (b) researching relations between supplementary angles using DGE.

To give another example, with the application sharer *My AppSharer*, via Bluetooth there is no further need to be connected in order to use a DGE. That restriction on connectivity has been overcome, and we can generate new forms to produce and develop new mathematics with such devices. Among the pedagogic strategies, there are multitasks, the possibilities and unfolding of a situation in which the students, individually or in groups, can develop, from their own interests, their own tasks and other subjects of study. We have to continue researching and creating environments to raise awareness among parents, students and teachers about the importance of the pedagogical use of MDwT.

CONCLUDING REMARKS

In this article, I have suggested six dimensions that can apply to teaching practice as well as research with MDwT. The dimensions are not hierarchical or ordered. They have both specificities and elements in common. For example, I could situate connectivity in each of the six dimensions, but I have chosen a line of argument that stems from aspects that can be differential to sustain each one of the dimensions separately. Alternatively, yet, connectivity could be thought of as a dimension in its own right. So, dimensions, with the reflexive organization that I have drawn here, are not categories. Nevertheless, although they lack a defining shape, they are equally relevant as they draw in their different implications to human development.

As it is in the dimension of contemporaneity that the subjects are invited to reflect on the various darknesses of their times (Agamben, 2009), on all that makes them feel fear, insecurity, pleasure with technological advances, and so on, all the other dimensions could be included in this one. Because, among other things, the reflection of what it means to learn must be in the central position of studies aimed at schooling.

Learning nowadays cannot be seen as the same process as it was 20 years ago. It is usual to hear comparisons between current learning as compared to more remote processes. Does that mean that people nowadays are not learning? How can a person play and win at electronic games and fail mathematics at school? Miracle solutions like universal curricula or results evaluated from a large-scale assessment policy are not promising of qualitative changes in our Education. I argue that there would be a real, effective possibility of improvement with investment in teachers' continuing education, improving both working conditions for teachers and school infrastructure, so that curricula can value creative processes of interaction and collaboration, would offer some actual possibilities for improvement as well.

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