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Tracing the Development of Touchscreen Education:

How Young Children's (0-10 Years) Appropriation of New (Touchscreen) Technologies is Leading Us to Revisit Our Teaching Strategies and Vision of Learning

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ABSTRACT

After a brief introduction pointing up the technological origins of humankind, in the main body of this paper the authors bring three different levels of analysis to bear on 0-10-year-old children's appropriation of touchscreen technology (in the home, during informal exchanges with peers, and at preschool and primary school). First, they review the most recent literature on the topic, showing that the age of first access to this kind of technology has dropped significantly; this suggests the need to provide a critical education in technology from the early childhood education and preschool stages onwards. Indeed, the data and evidence that is accumulating from home and educational contexts prompts the authors – in the second part of the paper – to revisit Sherry Turkle's classical three-phase model (informed by the work of Papert and Piaget) of how children encounter and relate to "new" digital technologies. Furthermore, the uses that children make of digital devices and the relative cognitive patterns need to be interpreted in light of the epistemological requirements that have driven both the development of these technologies and changes in the dynamics of how they are appropriated. All these levels of analysis are prerequisite to designing educational models that are truly enhanced by the deployment of touchscreen technology. Finally, in the third section of the paper, the authors outline the key principles of their own proposed model – the Bayesian Classroom – based on the theoretical considerations previously outlined.

KEYWORDS

Bayesian Classroom, Cultural Evolution, Teaching Strategies, Touchscreen Technology

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1. INTRODUCTION

The arguments presented in this paper were jointly developed by the two authors; more specifically, Sections 1.2, 1.3 and References were written by P. M. Ferri; and Sections 1.1, 1.4 and 1.5 by S. Moriggi.

1.1. We are Technological by "Nature"

According to a statement paper by the French Academy of Sciences on the relationship between the various types of screen that have marked key stages in the development of digital technologies and children's (0-10 years) learning over the past two decades: "As in all other areas of human culture, education remains the most powerful technology that humankind has yet developed for the transmission, acquisition and enhancement of knowledge" (Bach, Houdé, Léna, Tisseron, 2013).

Now such a statement, especially in an era that is increasingly pervaded by devices offering Internet connectivity – and (consequently) new cognitive, communicative and relational practices – supports the hypothesis that there is an ontological leap between the merely instrumental nature of our relationship with technology and the value of any educational (or didactic) model (whatsoever).

To put this another way, on the one hand we have increasingly sophisticated machines, which it makes sense for us to exploit in order to facilitate or speed up our daily tasks; but at a higher level, educational values – in no way undermined by the pressing pace of scientific progress and technological obsolescence – remain intact, a fixed and incorruptible point of reference that can help us to find our way through a world in a constant state of flux.

In any case, this dichotomy may be resolved via a more scientifically informed perception of our relationship with technology of all kinds, including the more basic. If instead of viewing scientific advances as a mere sequence of concepts, definitions, formulas and theorems serving to carry out tasks, we see them as complex and powerful categories of analysis and criticism, we will more inclined to take on board the fact that education is a technology to all intents and purposes – and that vice versa – educational models could never have been developed without reference to the technologies that made them feasible, not to say necessary.

This type of analysis has been conducted, for example, by the Nobel prize-winner for Medicine (1974) Christian de Duve (1917-2013), who – in his *Life Evolving: Molecules, Mind and Meaning* (2002) – provided a rigorous and clear account of the complex interplay between *nature* and *culture* that has marked the history of our species.

The Belgian biochemist noted the growing consensus in the international scientific community that "toolmaking played a key role in the development of the human intellect, by way of an evolutionary to-and-fro between hands and brain" (de Duve, 2002). More specifically, de Duve argued that, "freed by bipedal walking, the hands came to serve to a greater extent for prehension" (de Duve, 2002). In other words, from our ancestors' point of view, up to that point "things" had still not become *objects* (in the etymological sense of *ob-jecta* or "throw against") let alone tools. It was the newfound ability to hold, manipulate and use things, and thus to modify aspects of the environment, that enabled the development of a lexicon of gestures and actions – and consequently, of forms of conceptual thinking that up to then would have been impossible (Mead, 1934).

But this is not all. De Duve went on to claim that: "The gestures thus accomplished often being beneficial to the preservation and propagation of the species, any genetic modification tending to make the use of hands more efficient had a good chance of being retained by natural selection". And again: "Improvements acquired in this way could have been anatomical, such as the opposing thumb. But they also, and perhaps most frequently, could have affected the cerebral mechanisms governing the gestures" (de Duve, 2002).

De Duve's analysis clearly suggests that from the development of the opposing thumb to the production of state-of-the-art digital devices, each further reinforcement or specialization of feasible actions for our extremities, has invariably been accompanied by the possibility of thinking about doing that which had previously been unthinkable (in practical and, therefore, in conceptual terms) because undoable. Therefore, new conceptual perspectives should be understood as emerging from new practices enabled by increasingly sophisticated instruments, and this is also and especially true in the field of education and teaching.

While – as observed by de Duve in more historical terms – "the search for knowledge has long been preceded by purely practical preoccupations" (de Duve, 2002), two other key aspects should also be noted: a) the fact that in the history of human evolution "success often came before understanding" and that, as a result, b) "from these empirical, utilitarian roots, there was born, in the course of time, a new form of explanation of the unknown, which has become modern science" (de Duve, 2002).

In other words, it is crucial to appreciate that *Homo sapiens* has *become what he is*, as Nietzsche might have put it, through his interaction with the tools that have marked and enabled the various stages in his cultural evolution.

Clearly, on the one hand, this rule out the possibility of viewing technology as a "foreign body" with respect to the supposed "naturalness" of "being human"; and on the other – as suggested above – invites those seeking to advance understanding of the human being, its modes of relation and styles of learning, to investigate the (apparently oxymoronic) technological nature of humankind (Moriggi-Nicoletti, 2009).

1.2. Children Go Touch...

This crucial link between human beings and technology is even more apparent in the field of schooling and education. Today's educational institutions bring together two anthropological species with somewhat different approaches to teaching and learning.

On the one hand, we have teachers who still live and function entirely in the Gutenberg Galaxy and, on the other, new generations of students who have inhabited the Internet Galaxy since birth, and done so with spontaneous ease (Castells, 2001). Indeed, the last twenty years have seen radical discontinuity at the macro-social and economic levels: we have gone directly from the advanced services society to the "information society" (Castells, 1996). This radical transition has also impacted, although in Italy perhaps not quite yet, on the dynamics of teaching and learning. Children, up to the age of at least 12/13 years, embody and represent the logic and dynamics of digital culture – the outcome, as mentioned in 1.1, of widespread and continuous interaction with all kinds of digital devices, particularly those based on touchscreen technology.

Whether or not we opt to refer to these children as "digital natives" (Ferri, 2011, 2014), the practices that give form and substance to their experience of the world (including their learning experiences) have been rewritten using a new lexicon of relationships and meanings that are often mediated by digital language. Thus, contemporary education – starting from the preschool and primary levels – either needs to sustainably incorporate children's new languages; or risk losing much of its efficacy (Ferri, Moriggi, 2015). A privileged perspective on the extent of the phenomenon may be obtained by reviewing international research data on the spread of touchscreen devices among young children.

Today, a truly vast number of children between the ages of one and twelve years interact with some form of touchscreen. More specifically, the statistics show that children's use of interactive screens has increased sharply at the international level, both in the home and in educational settings (Eu Kids Online, 2014 www.lse.ac.uk/media@lse/research/EUKidsOnline/Home.aspx, EU, Eurydice, https://webgate.ec.europa.eu/fpfis/mwikis/eurydice/index.php/Main_Page). And this trend also applies to infant-toddler centres and kindergartens, although the introduction of these devices into early childhood education contexts is taking place more gradually, and has generated greater debate (European Commission, 2012)[1].

Clearly, the situation can vary widely from one country to another: nonetheless, we know that in Europe over 92% of families with children have an Internet connection (Eurostat, 2015) and that, as early as 2014, again at the European level, 42% of 6-year-old children and 52% of 7-year-old children had access to Internet (European Commission, 2014) – a figure that has predictably continued to grow.

A finding of great importance is that the number of Internet connections in Italy is now greater than the number of notebooks and personal computers. This is accounted for by the growing penetration of devices such as smartphones and tablets especially among younger children. Again, the European data can shed light on how the Internet revolution has brought about rapid growth in the diffusion and use of these devices in families with young children (0-6 years), providing information on the broader context in which this trend has taken hold.

The most authoritative European source on this specific theme – the *Eu Kids Online* study (http://www.lse.ac.uk/media@lse/research/EUKidsOnline/EU%20Kids%20Online%20reports.aspx, Green and Livingstone, 2014) – reports on the one hand a marked increase in the number of children under eight years old with access to Internet; on the other hand, it points out that children in the 9-12 years age group are increasingly engaging with and using digital technology in the same ways as their older siblings (12-15 years). In practice, this means that almost 100% of children aged 9 year and older are "connected" to Internet.

Nevertheless, in our view, the most significant outcome of all is the finding that most Internet access takes place via touchscreen devices. Recent data, for example a study conducted by the Einstein Medical Centre in Philadelphia (Kabali et al., 2015), shows that 36% of US children under one year frequently interact with a smartphone or tablet. A similar trend has also been observed in Europe. Indeed, as early as 2013, it was found that 50% of Swedish children of 3-4 years used a tablet and 25% a smartphone (Findahl, 2013). In 2012 in Norway, 23% of 0-6 year-old children had access to a touchscreen device in the home – and it was estimated that in 32% of these cases the first use of a touchscreen occurred before the age of 3 years (Guðmundsdóttir & Hardersen, 2012). In addition, a quali-quantitative study conducted with 575 parents (Ofcom, 2013) suggested that touchscreen devices were very popular among 3-6-year-old children; parents reported that touchscreens were far easier for children in this age group to use than were notebooks with touchpads – let alone digital devices requiring the use of a mouse (Ofcom, 2013). And it is not difficult to guess the reason for this: it is much more intuitive for the hand to interact directly with the screen than to rely on the mediation of a device requiring more complex and indirect eye-hand coordination.

1.3. Turkle "Reloaded": A Model of Explanation for the Lowering in Children's Age of First Access to Interactive Screens

Thus, the so-called digital natives grow up surrounded by a landscape of objects and meanings, in which the touchscreens of smartphones and tablets, initially those of their parents' and subsequently their own, are the rule rather than the exception (Prensky, 2013). Internet is one of our children's mother tongues, as borne out by another *Eu Kids Online* study – significantly entitled: Mobile Opportunities. Exploring positive mobile media opportunities for European children – in which the author, psychologist Jane Vincent, analysed 2010 and 2014 data from a series of surveys conducted under the *Eu Kids Online* project (Vincent, 2015), reporting amongst other findings that Internet plays a key part in the self-identity of digital natives.

The theme of how interaction with digital technologies affects children's subjective experience had previously been addressed by Sherry Turkle in the early 2000s (Turkle, 1996, 2006, 2011). More specifically, Turkle identified three phases corresponding to the "systems" through which children encounter, use and relate to technology. Informed by the educational and psychological traditions of Piaget and Vygostsky respectively, she proposed: a) a metaphysical phase: between 3 and 8 years of age. When children in this age group encounter computers they are typically seeking answers about life, and thus even in relation to digital devices they will ask: "Can it think?", "Can it feel?", "Is it alive?".

b) a mastery phase: from 7-8 years onwards, according to Turkle, children are more interested in gaining mastery over the world than in speculating about the bigger questions in life. Their earliest opportunity to master a digital device often involves playing a videogame: they are mainly preoccupied with testing their own competence and capacity for action. They do not engage in reflection, but are focused on playing, mastering and winning the game. The computer offers them a means of becoming more independent. The key question preoccupying them at this stage is: "What can I do with the computer?"

c) identity phase: from adolescence onwards, the appropriation and mastery of new skills, while still important for life, becomes a synonym of identity: some teenagers' identity is based on their competence at school or in sport, but mastery of the languages of technology can also offer security and appeal, in certain cases to the exclusion of other interests. During this phase, the focus of reflection is the self, and the typical question is: "Who am I?"

Some years on, Turkle's analysis remains meaningful; however, considering the data reported and analysed above (1.2), it seems appropriate to redefine these phases in line with the younger ages at which children now enjoy access to touchscreen devices. Based on the theoretical background outlined above and the most recent empirical data, it seems reasonable to propose moving Turkle's first phase (metaphysical, philosophical) to 1.5-3 years; the second (mastery) to 3-8 years; and the third (identity) to early pre-adolescence.

This said, Truckle's research remains a valuable point of reference that clearly illustrates the – almost "natural" – progression from an exploratory approach to technology to a more competence-based and communication-oriented one. This theoretical stimulus encourages us – as indeed does all our analysis to date – to take up the challenge of seeking out models and strategies designed to facilitate the mindful and critical appropriation of touchscreen technologies, in both formal and informal contexts.

1.4. From the *Flipped Classroom* to the "Bayesian Classroom"

The fact that children are enjoying an increasingly precocious relationship with touchscreens, which in turn is increasingly contributing to structuring the self (Bach, Houdé, Léna, Tisseron, 2013), has also led to changes in modes of learning. Distinctive new cognitive styles are emerging, and this represents both a challenge and opportunity for educational research. In fact, the communication and online interaction practices mediated by interactive screens appear to fit with educational approaches such as learning by doing (Dewey, 1938) and contemporary social constructivism (Ferri, Moriggi, 2014). However, we argue that such approaches need to be revisited in light of the epistemological factors that drove the very invention and (consequent) spread of Internet. Hence, in order to explain the rationale for our proposed educational approach, we now briefly summarize the context from which Internet emerged.

In 1984, Timothy (Tim) Berners-Lee took up a fellowship at CERN in Geneva, where he was assigned to a team with responsibility for gathering the results of all the experiments being carried out at the research institute. Tim found himself in a familiar situation. He had previously worked for CERN as a consultant and, at that earlier time, had already been asked to "catalogue the connections among the ten thousand or so researchers" (Isaacson, 2014). The young researcher soon developed the insight that the IT project he was working on should be aimed not only at digitally storing and organizing a growing patrimony of scientific data and evidence, but also at "enhancing" the level of cooperation within a vast and complex research community.

"I've always been interested in how people work together" Berners-Lee has since stated in an interview (Isaacson, 2014). "I was working with a lot of people at other institutes and universities, and they had to collaborate. If they had been in the same room, they would have written all over the blackboard. I was looking for a system that would allow people to brainstorm and to keep track of the institutional memory of a project" (Isaacson, 2014). Since his time as a physics student at Queen's College, Oxford, Berners-Lee had been convinced that cooperation was an integral part of knowledge acquisition. "You got half the solution in your brain, and I got half in mine. If we are sitting around a table – he explained to Isaacson – I'll start a sentence and you might help finish it … Scribble stuff on whiteboard and we edit each other's stuff" (Isaacson, 2014).

A simple and intuitive description of a modus operandi which nevertheless reproduces in the form of daily collaborative practices some of the distinctive and founding characteristics of modern scientific knowledge per se. More specifically, this knowledge is – for the first time in human history – public, open to review and verifiable: reviewable because it is verifiable and verifiable because it is in the public domain.

Thus, close analysis of the history of Internet clearly suggests that this tool both embodies and enhances the internal dynamics of how scientific knowledge is progressively refined and expanded. Consequently, even the extremely brief account given here suggests that it would be at best naïve to launch educational projects or implement classroom settings that use Internet as a tool, without taking into account the cultural background that enabled (and demanded) its invention.

In other words, Internet technologies will contribute to enhancing education to the extent that web-based learning models and spaces incorporate the learning and relational/interactional strategies of a research community.

Thus, just as Berners-Lee wished to "build a creative space, something like a sandpit where everyone could play together" (Isaacson, 2014); in the narrower school context also, we need to redesign physical and digital spaces in which learners can play together following the rules of good research practice. However, redefining these spaces presupposes a specific epistemological approach (based on the logic of scientific discovery) in which previously acquired concepts are routinely "used" as instruments of learning.

We ourselves have brought such a perspective to bear in developing a detailed and systematic methodological proposal that has been reported elsewhere – the *Bayesian Classroom* (Ferri, Moriggi, 2014) – and is designed to foster the changes in outlook and practice required to bring about a gradual and sustainable transition to technologically-enhanced teaching methods. Our proposed method is a reinterpretation of the *Flipped Classroom* (Bergmann, Sams, 2012; Fulton, 2012; Bishop, Verleger, 2014) informed by some of the key principles of Bayesian epistemology. With a view to "flipping" the traditional transmissive approach to teaching, we too suggest dividing school-time into three phases, with the following specific characteristics:

1. **Toolbox:** This is the design phase during which the teacher selects appropriate educational materials in a range of digital formats and languages and uploads them to the class's virtual learning environment;
2. **Cooperative Problem-Solving:** The learning materials and worksheets are chosen and designed with a view to facilitating and stimulating the learners, working in small groups, to actively draw on their existing competences and use the contents of the learning environment as tools – as recommended earlier in our analysis. It is this drawing together of the conceptual and the operational (typically associated with the use of virtual learning environments) that enables the traditional classroom setting to be "flipped", because it introduces the same logic of shared discovery (typical of scientific and technological endeavour) which – as we have seen – played a key role in the invention of Internet;
3. **Situation Room:** In this third phase, the teacher sets up a discussion session during which the students share and analyse the findings of the individual "research teams". The aim here is to foster and enable practices of active criticism and reciprocal verification of the outcomes obtained and hypotheses developed. This is the most dialectical phase of our proposed educational model, that in which the products of the students' cooperative efforts are made "public" (and therefore verifiable and reviewable).

However, to bring to the fore some less evident features of this interpretation of the *Flipped Classroom* model, in the final section, we outline, albeit in purely qualitative terms, salient aspects of the "logic of the uncertain" discussed by de Finetti (1989) and informed by the well-known "rule" developed in the eighteenth century by the Presbyterian clergyman Thomas Bayes (1702-1761).

1.5. "Epistemological Tolerance" as the Foundation of Teaching

The above cited formula, also known as the "theorem of probability of causes", is derived from two other key theorems: the theorem of composite probability and the theorem of absolute probability[2].

In general, Bayes' "formula" offers a means of reviewing and extending knowledge by choosing between alternative (or conflicting) hypotheses based on a rational review of the available options. Such a subjectivistic approach to the calculation of probabilities bears great heuristic force and, for this very reason, we believe that applying it to the type of learning activity described above will offer teachers and students a conceptual framework for the correction and refinement of their working hypotheses (and consequently their degree of confidence in these hypotheses) in light of new information or research findings. In other words, the implicit epistemological approach that is formalized in Bayes' theorem can enable the development (or revisiting) of cooperative learning activities and practices informed by a critical approach – which as the physicist Carlo Rovelli (drawing on the practical and theoretical work of Italian mathematician Bruno de Finetti[3]) has usefully observed – may also be described as the "prudent and rational management of our ignorance" (Rovelli, 2013).

Indeed, this heuristic perspective assumes that it is not possible to assign objective probabilities to events/hypotheses (Bayesian scepticism). Rather, probabilities are seen as subjective degrees of confidence on the part of the researcher (degrees of belief). Hence, Bayesian epistemology takes into account the reality – not to be overlooked – that within a research (or study) group, it is highly unlikely that diverse individuals will initially approach a given topic or problem with the same degree of subjective confidence. In other words, rarely will a group of subjects be willing to adopt the same starting (research or working) hypothesis and with the same degree of confidence in it.

Adopting a heuristic approach such as the Bayesian method can therefore educate students to learning (in a rational and collaborative manner) from experience, in terms of reviewing (corroborating, correcting or confuting) the information and concepts acquired during their research, and consequently, reviewing their degree of confidence in their initial (*a priori*) hypotheses. This should enable and encourage them to identify a rational basis for selecting the best alternatives among the range of hypotheses from which the (research or work group) started out. This is because, although individual group members may initially have held very different subjective (*a priori*) degrees of confidence to one another, a sufficient quantity of observations / research / argumentation (and therefore of shared revision of hypotheses) will lead to them to identify (*a posteriori*) likelihoods – and therefore degrees of confidence – that are increasingly convergent (Ferri, Moriggi, 2014).

Closely related to this aspect is another characteristic feature of (our) reinterpretation of the *Flipped Classroom* from a Bayesian perspective. Namely, the fact that researchers (students) cannot *a priori* reject hypotheses that are alternative to (or in conflict with) their own, including more unusual and/or minority proposals. This attitude is not underpinned by a moral approach, that is to say, a question of respect for those who hold different opinions, but is rather an exercise in epistemological tolerance. No member of a (work or research) group can technically exclude or reject any hypothesis in the absence of data or arguments justifying such a move.

The teacher's role during the so-called cooperative problem-solving stage is mainly to supervise and guide the research groups throughout the rational (and cooperative) process of reviewing their hypotheses, with a view to educating them to active learning based on exchange and the principle of *epistemological tolerance*. As the groups go through iterative cycles of critical and shared learning, they will become progressively better at exploiting the diverse talents of individual group members. Furthermore, good quality guidance from the teacher during this phase of group (and individual) work is vital to laying the ground for the following phase of presentation and comparison of outcomes: the Situation Room.

Thus, the proposed methodological framework, on the one hand allows us to incorporate "new technologies" into educational contexts by appropriating their cultural roots (see Section 1.4); on the other, by interpreting the logic of discovery from a Bayesian perspective, it aims to go beyond traditional transmissive teaching styles to develop learning strategies and activities based on the concept of epistemological tolerance. The last-mentioned approach is crucial to models of active and cooperative learning, which may be adapted to suit the needs of children at different levels of education.

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ENDNOTES

[1] Italy is somewhat the exception vis-à-vis the more developed European countries, in that, according to the Istat survey “Cittadini, imprese e ICT” [Citizens, Businesses and ICT] (2015), from 2014 to 2015 the percentage of families with home Internet access and a broadband connection increased from 64% to 66.2% (home access) and 62.7% to 64.4% (broadband), respectively. The same study found that families with at least one child under eighteen were the most technologically equipped, with personal computer ownership at 87.1% and home Internet access at 89% among this group in 2015 – and these figures had remained stable with respect to the year before (Istat, 2014).

[2] For in-depth background on themes and issues associated with Bayesian logic, see Hacking (1975).

[3] See, for example, de Finetti (2006).

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