

DIALOGUE IN COGNITIVE SCIENCES IN THE FACE OF THE COEDUCATION CONTROVERSY

El diálogo en las ciencias cognitivas frente a la controversia de la coeducación

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Abstract

The aim of this paper is to reflect on neuroscientific research in relation to sexual difference. The interest in this reflection is to address the debate on coeducation. The methodology used is fundamentally based on the review and contrast of the texts and theories that have starred in the debate in the last decade. In that time a controversy -already raised in the past- has emerged with force, on the pertinence of proposing again an education segregated by sexes as opposed to coeducation. In order to unravel this knot, we will see that, not only neurosciences will be important in what they tell us about our brains, but it will also need a critical view that must come from both a self-criticism of the neurosciences themselves, as well as from other disciplines, and very especially from the philosophy of education.

In this sense, the set of cognitive theories will have to engage in an open and constant dialogue to comprehend important aspects that the neurosciences alone cannot respond. Therefore, a proposal from the so-called neuroeducation not only cannot ignore this transdisciplinary dialogue, but should, in some way, be able to lead it. Finally, the question will be what we understand by education and what philosophy of education we advocate. It is precisely this transdisciplinary view, rather than a unidirectional discourse of neurosciences or neuroeducation determined by the neuro jargon, what can make us assert that coeducation is the answer.

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Keywords

Coeducation, cognitive sciences, neuroeducation, sexual difference, sexism, education.

Resumen

El objetivo de este artículo es reflexionar sobre la investigación neurocientífica en relación con la diferencia sexual. El interés en esta reflexión es abordar el debate sobre coeducación. La metodología empleada se basa fundamentalmente en la revisión y contrastación de los textos y teorías que han protagonizado el debate en la última década. En ese tiempo ha surgido con fuerza una controversia, ya planteada en momentos pasados, sobre la pertinencia de proponer de nuevo una educación segregada por sexos frente a la coeducación. Para deshacer este nudo se verá que, no solo las neurociencias serán importantes en lo que dicen sobre los cerebros, sino también será necesaria una mirada crítica que ha de proceder, tanto desde una autocrítica de las mismas neurociencias, como de otras disciplinas, y muy especialmente desde la filosofía de la educación. En este sentido, el conjunto de teorías cognitivas habrán de estar en un diálogo abierto y constante para conocer aspectos importantes que las neurociencias por sí solas no pueden responder. Una propuesta desde la llamada neuroeducación no solo no puede obviar este diálogo transdisciplinario, sino que debería, de alguna forma, poder liderarlo. La cuestión finalmente será ver qué se entiende por educación y qué filosofía de la educación defendemos. Es precisamente esta mirada transdisciplinar, más que un discurso unidireccional de las neurociencias o de una neuroeducación determinada por la jerga de lo neuro, lo que nos hará apostar por la coeducación.

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Palabras clave

Coeducación, ciencias cognitivas, neuroeducación, diferencia sexual, sexismo, educación.

Introduction

This article aims to reflect on neuroscientific research in relation to sexual difference: the main objective of this work is to address the debate on coeducation. For this, a review and contrast of the texts and theories that have featured in the debate in the last decade is carried out. In recent times, a controversy from past eras has resurfaced about the relevance of, once again, proposing a sex-segregated education as opposed to coeducation. The article will first present, as a state of the art, the main lines of argument for the positions under debate. Afterwards, transdisciplinary dialogue will be proposed as a method to advance an understanding between neuroscience and the philosophy of education. The discussion of the article will focus on seeing how this dialogue helps to solve the question about sexual differences in the brain in terms of education. All this will guide the conclusion towards a bet on coeducation and in constant dialogue with neuroscientific theses on brain plasticity.

Scientific evidence regarding the difference between the sexes at the level of intelligence and innate abilities associated with sex, according to leading neuroscientists such as Vidal (2012), Jordan Young (2011), Hyde (2016) and Rippon (2019) and some studies from Hyde (2005, 2006, 2007) with metadata that confirms it, is null or very poor. That is, there is no

scientific way to maintain that the brain is binary in terms of sex. The fact is that the brain does not speak in a binary way, as the social language does through the genders ‘man’ and ‘woman’. Still, there is a long tradition of believing that there is such a difference. This belief, which can be called bluntly ‘pseudoscientific’, continues to be present in many medical and human biology manuals, and even today, it remains an important stream of scientific research, according to Rippon (2019). Research to better understand brains and their differences, sexually or otherwise, is a valuable goal and can provide the necessary knowledge to progress in self-awareness as humans, and to better understand what the human being is and what it can become in an even transhuman sense, as Haraway (1991, 2016) proposes. However, that research should not be confused by the long and well-known tradition in the history of science, of trying to find a natural difference between female and male brains in order to naturalize social and cultural differences (and sometimes inequality).

There is profuse documentation regarding that studies such as those of Schiebinger (1989), Russett (1989), or Laqueur (1994) give about the construction of sexual difference based on a pre-constructed idea about the body of women, and other human minorities (such as black people), which are clear testimonies of not-knowledge that is erroneously called ‘science’. They are the ‘scientific lies about women’ as García Dauder and Pérez Sedeño (2017) have called them. The concept of ‘epistemologies of ignorance’ of Tuana (2004, 2006) can fit very well to explain this practice, which is at the foundation of the nature/culture debate, centered and reconverted in the sex/gender debate, as recognized authors such as Haraway (1991) and Fox-Keller (2010) have been responsible for targeting.

According to Tuana’s concept, the construction of knowledge is linked to power practices in which the same scientific institution is often a participant. These power practices imply anomalous behaviors in scientific activity. These can range from the same bias in the design of experiments to inconsistent or poorly proven conclusions, as neuroscientists such as Rippon (2019) or Fine (2017) have recently pointed out.

The prejudices that guide these practices are intertwined and reinforced by the pressure of scientific journals to publish works and experiments that affirm sexual differences in the brain, as the scientists Rippon et al. point out in a joint article. (2017). That is, and as these scientists declare, scientific journals accept results of experiments that lead to affirming findings, however minimal, of brain differences between the sexes, rather than conclusions that there are no such differences. The percentage of rejection of scientific articles according to whether sexual differen-



ces in the brain are affirmed or denied is evident, as Kaiser et al. (2009) affirm. This of itself is already negative since it prevents a contrast that is part of scientific excellence. The fact that scientific articles on similarities in human brains are not normally published, discloses and reinforces an idea that it is scientific to assume that there is such a sexual difference in brains. But there is—in addition—an aggravating factor, and that is that this type of investigation usually reaches the media, later, in an exaggerated and striking way. It does not seem news to say that no brain difference has been found with respect to the sexes. However, saying, as Brizendine states (2006), that “women speak more than men” is striking and confirms what is assumed to be true; which comforts and allows living in a real cognitive framework because it is in accordance with held beliefs. Maney (2015, 2016) observes how the press disseminates published findings on this subject with inappropriate messages, and that the conclusions of scientific articles are often manipulated or exaggerated. In the specific case of the experiment that we have just cited on the loquacity of women and men, it reached the press with headlines such as: “They find the cause of female verbiage” (ABC, 02/22/2013). This type of language is not only scientifically unjustified, but it is also a serious drawback when it comes to being able to advance and truthfully disseminate neuroscientific research, as O’Connor and Joffe (2014) point out. In this specific case, in addition, a later study by Mehl et al. (2007) with 396 participants, compared to Brizendine’s ten, stated that it could not be concluded that one sex speaks more than the other, since the mean is similar for both. The author, Brizendine, retracted, but the generalist press no longer echoed, neither the subsequent experiment that annulled her conclusions nor Brizendine’s retraction.

These grotesque, but common cases, of the transfer of scientific research to the press, confirm the need for more demanding standards when reporting headlines to the generalist media. The humanistic and social disciplines, such as journalism, sociology, philosophy, education, and communication sciences will have to take into account how to disseminate, interpret, and apply conclusions from scientific experiments. Thus, Maney (2015) recommends avoiding terms that exaggeratedly mark illegitimate conclusions. Talking about ‘deep’ or ‘essential’ differences between scientific findings in relation to brains previously classified into two sexes has zero scientific evidence, as Jordan Young (2010) or Kraus (2011) have stated. Even so, these practices of exaggeration of results interpreted in an exaggerated way by the media are still common, with which an illegitimate use of scientific authority is made, by taking



for truth something that is intended ‘natural’ and innate when there is no evidence of this, as Reverter affirms (2016).

All these illegitimate practices lead to the need to reaffirm something that the same institutions have been demanding for a long time, and it is the urgency of a more open science, with other more collaborative systems when projecting, experimenting, concluding, and publishing; better filters and more transparent when evaluating and publishing; and more funding to be able to do, not just more, but better science. The current global crisis due to the coronavirus pandemic has reinforced these demands, and perhaps it will serve to raise awareness among citizens, governments, and institutions to invest in developing more solid scientific systems, as the UN itself is promoting.

Large projects such as the *Human Brain Project* (European Union) and the *Brain Initiative* (United States), a consequence of the declaration of the 1990s as the *Decade of the Brain* (Goldstein, 1990), have led to a growing interest in sciences by capturing grants through brain research. This has led, at times, to excessive confidence and growing expectations about the real possibilities of being able to fully explain the human being through its description, as Rose (2006) and Rose and Abi-Rached (2013) report. However, and as Roger W. Sperry (1981) himself warned when he received the Nobel Prize in 1981 for his research on the functional specialization of the hemispheres of the brain, neuroscientists must change their priorities and emphasize the possible social benefits of their research.

With this idea of analyzing the social aims of science and, at the same time, freeing scientific research about the brain from the spurious constraints that research on sex differences in the brain may entail, there has been growing criticism from some women neuroscientists about these bad practices. For a decade they have been organized in a collective to denounce how scientific journals and some of the agencies that invest in scientific research only have an interest in publishing in relation to sexual differences in human brains if it is to affirm that such difference exists, and never to deny or even question it. The so-called *NeuroGenderings Network* (NGN), which emerged in 2010 at a congress in Sweden, has become a growing group of scientists based in different universities and research centers in different countries, who carry out surveillance work regarding scientific publications about the theme of sexual difference in the brain. In a task that I called ‘epistemological guerrilla’ (Reverter, 2017), what they do is propose concepts and debates that can serve as a guide for the necessary dialogue between neurosciences and social and educational interests.

The main purpose of doing the task of monitoring what is published in relation to this topic is not to deny, in a prejudicial way, possible differences between the sexes and in relation to the brain, but to warn the need for a truly scientific and objective practice, both when planning or designing experiments and drawing conclusions, as well as when publishing them and transferring them to the generalist and popular media. For this reason, it is convenient to review and adjust new methods that can validate good science. As Roskies (2002) herself stated in her prominent article *Neuroethics for the New Millenium*, understanding the mechanisms of the brain in human behavior has potentially 'dramatic implications' for our perspective on ethics and social justice. For this reason, neurosciences and the rest of the involved cognitive sciences will have to be interested in investigating and finding out, not only questions related to the knowledge of the different academic disciplines but also moral and social questions (Reverter, 2019). And in this area the question of the differences and similarities of the brains of men and women becomes essential.



Transdisciplinary dialogue as a method

It has already been commented that the two most important projects worldwide financed with millionaire funds, both public and private, in relation to brain research are *the Human Brain Project* and the *Brain Initiative*. Both projects not only have neuroscientific objectives that allow a better understanding of the functioning and nature of the human brain but are also made up of teams of researchers from other disciplines who try to study the ethical, social, political, and educational implications of brain research. It is an interdisciplinary vision that takes into account concerns about the effects and consequences that research on the human brain may have for the entire human species and the entire life on the planet. In both projects, there is a priority in meeting the needs from the point of view of the interests of the human species and the ecological environment in which we live. It is, therefore, that scientific concern about the brain must be connected with a more complete vision of the world that it creates and in which it evolves. For this reason, there is an impact on a way of understanding the projects they develop within a framework of science that takes into account civil society and the human community, in harmony with the rest of life on the planet. Therefore, both projects have a vocation that they define as democratic and egalitarian.

In reality, this interdisciplinary vocation is not new. It should be remembered that the society that is indicated as the origin of Neurosciences as a discipline, the Society for Neuroscience (organized in 1969 and as stated on its website), developed in the 70s an ideology that led to shaping this new discipline as 'an intellectually and methodologically open field in which neither approach was privileged over the other', thus avoiding 'parochialism and traditional isolation' of the disciplines. The idea was, from the beginning, to serve a human horizon of equality.

This initial idea of neuroscience is far from the deterministic idea that thinks that a finding in the brain has to be translated into a mandate in the social field. This obsolete determinism as an idea and principle, which is so rejected in many scientific fields, continues to be maintained, many times, in ideas as deeply rooted as the belief in sexual difference. And, for this reason, the work that I have called 'epistemological guerrilla' is still necessary.

The interdisciplinary dialogue between the sciences, and specifically, between all the cognitive sciences, summoned to dialogue on education is so necessary that if it is not given, it is simply not possible to understand what to do with the knowledge that is discovered and constructed. And this is not only a "schooling" need, which would be enough, but it is a global urgency. Precisely, one of the effects of the confinement of the population in times of pandemic has put on the table the urgency to rethink education in a way that there has never been before. And for this, it will be necessary to overcome practices of generating knowledge and education that are simply no longer useful, that do not serve to prepare a better world, or are even part of the problems that exist.

Looking back at the 60s and 70s of the 20th century, one can see how what was called 'the debate of the two cultures', starring mainly Snow (1959) and Leavis (1962), left the conclusion that the separation of knowledge is a bad method. It gives a bad orientation to knowledge; what's more, that separation is disorienting. It is, therefore, a true methodological error not to maintain, promote, and seek an interdisciplinary dialogue, as stated by Nussbaum (2010).

In the impressive two-volume study that Burke (2000, 2012) carries out on the social history of knowledge, from Gutenberg to Wikipedia, he gives many keys to understanding that a serious problem of knowledge is hyperspecialization, which leads to intellectual insularity. In a world like the current one, with serious and complex problems at the planetary and human species level, this narrow-mindedness of isolated and fragmented disciplines itself becomes a considerable inconvenien-

ce. It is imperative to understand a new form of knowledge generation that takes advantage of dialogue between experts, fosters imagination, and takes risks in non-disciplined border investigations. Given the complexity of the problems, there is a challenge that only this form of open and networked science will be able to respond, as Carbonell (2018) and Carbonell and Díez Fernández-Lomana (2019) have pointed out in their latest publications.

With this intention of linking neuroscience to its aspiration to be useful for an egalitarian project of society, a congress called *Critical Neurosciences* was organized in 2008 at McGill University in Montreal. The organizers, Suparna Choudhury and Jan Slaby (2012), are professionals in the field of social sciences who precisely with the term ‘criticism’ intend to turn around this obsession with the ‘neuro’ and the new techniques for scanning the brain that leave out that necessary philosophical, sociological and political reflection. Their concern appears when they realize that from supposedly neutral parameters, neural distinctions are being made between classes or categories of people. The growing medicalization of life and the progressive surveillance of bodies, together with scientific conclusions about what the human being is, can lead to a catastrophic drift for the project of creating a world with more equality and justice, as Rose warns (2006).

From this project of Critical Neurosciences they propose to introduce the term ‘critical’ in the way that Kant (2003) defended in *The Conflict of the Faculties*, in 1798. In other words, it is public order that constitutes the fundamental condition to be able to exercise the innate right that is freedom. Choudhury, Nagel, and Slaby (2009) complement this critical vision with the proposal of the Critical Theory of the Frankfurt School. Honneth’s (2009) concept of ‘social pathologies of reason’ will serve to formulate the conceptual framework that helps to “articulate a critical stance towards some methodologies, procedures, and practices of neuroscience today” (Hartmann, 2012, p. 67). And it is that Honneth, with the concept of ‘pathologies of reason’, precisely wanted to denounce the loss of meaning and the impossibility of drawing purposes and objectives at the level of the human community. Rescuing this ethical core for all rational action linked to any practice of scientific knowledge should be the goal of that interdisciplinary dialogue that is advocated here. All science, therefore, should be critical; or, rather, it should never stop being.



Analysis: Neurosciences and philosophy of education

Criticism as a practice will have to be applied, especially in the understanding of what we are in order to offer a philosophy of education that connects competently and in dialogue with the other cognitive sciences. From that critical vision, that space for dialogue will have to be created and given first-order validity. On the subject of education, it is the discipline called 'neuroeducation' that could fulfill this role. The authors that serve as references in this area are Battro and Cardinali (1996), Battro et al. (2008), Bruer (1997, 2008), Ansari et al. (2011, 2012), and Kitchen (2017). All of them, in fact, propose to think of neuroeducation as a necessary meeting of gazes at cognition, the brain, and education. This integration will allow new categories to emerge that allow a better understanding of how learning works and, therefore, how to educate. As Kitchen (2017) warns, a vision that simply replaced mind with brain would be as absurd as it is dangerous; and that is why, in the dialogue, the philosophy of education can clarify and propose new concepts that allow us to move away from a determinism that seems to tempt certain educational sectors linked to neurosciences, as Gracia and Gozávez (2019) also point out.

In this relationship, the important thing will be to determine: what orientation has the relationship between the fields of knowledge? Who guides the way? Is it a symmetrical direction? Is there a mutual influence? The philosopher and neuroscientist Northoff (2004) proposes a transdisciplinary avenue by proposing this dialogue between philosophical theories and scientific hypotheses. With this, he aspires to create a dialogue that is more than the mere synthesis and addition of some hypotheses and others. Fuentes Canosa and Collado Ruano (2019) explain very well the differences between the different models of dialogue between disciplines: multidisciplinary, multidisciplinary, interdisciplinary, and transdisciplinary. These authors analyze in detail and rigor each one of these models for the relationship between disciplines that intervene in the study of the mind, brain, and education. They conclude that, indeed, an evolution towards a transdisciplinary approach is needed. This will imply, not only dialogue but also mixing training, concepts, methodologies, and practices to generate new knowledge. As the metaphor of Breuer (1997, 2008) proposes, it is about creating bridges and not looking for foundations.

In this search for bridges, conceptual questions will have to be asked before turning on the scanner, as Harrison (2008) warns, and beginning to translate or interpret neuroscientific findings in terms of educational 'instructions'.



Discussion: Dialogue between neurosciences and education in relation to sexual differences in the brain?

The dialogue between neurosciences and education is taking place, not always in a transdisciplinary way, as is proposed here, but there are interesting experiences of this dialogue; such as Marina (2012), Mora (2013), Narváez (2016) or Carballo (2016). However, and as has been announced in the introductory part of this article, in research on sexual differences in the brain, and especially in relation to cognition, there are still patterns that do not meet the standards required in scientific practice, as many voices point out. And this is relevant when it comes to settling an educational debate of great interest.

Although it is true that the coeducation model is well established, both in public education and is a part of private education, it is no less true that the debate around the advantages of separation by sex in the classrooms has been manifested with force in the last decade. Those who advocate a return to a sex-segregated education rely on supposed scientific conclusions about how the sexual difference in the brain affects the ways of learning. Thus, they tend to infer that not only are there structurally and functionally different brains, in the sexual sense, but that the way of learning is, because of this, different. The most outstanding cases in this idea are North American authors, on the one hand, Michael Gurian and Kathie Stevens (2011), and on the other Leonard Sax (2005). The former not only affirm that sexual difference is confirmed, but that it greatly affects the way of learning, and that this is an issue that crosses all cultures, that is, it is innate to the human species. Both are part of the *Gurian Institute* and are dedicated precisely to spreading the idea that schools have to separate boys and girls in classes again. On the other hand, the psychologist Leonard Sax (2005), with the same degree of popularity as Gurian, maintains a constant campaign in favor of segregated education, because he says that it is the correct way to act according to the innate sexual differences in the brain. This segregated education is also proposed as a solution to many of the current problems, not only in education, but in almost any human environment.

But what does neuroscientific research say? It has already been commented that what it says is that there is no conclusive evidence to affirm that there is a difference between the male and female brains. It is true that the simple concept of 'sexual difference' is already a subject in itself for a long debate. What is meant by sexual difference today is unclear, although it never has been. As Laqueur (1994) brilliantly explained



in his book *Making Sex. Body and gender from the Greeks to Freud*, what is meant by sexual difference changes across time and across cultures.

For the sake of determining the question of education and whether or not to separate boys and girls, it can be taken for granted that there are two anatomically different sexes. The question then moves, because it is the issue that is approached as most relevant for education, to whether the sexual difference occurs in the brain. Let's see what one of the world's most prestigious neuroscientists, Margaret McCarthy (in Joel & McCarthy, 2017) tells us: "... the inevitable conclusion that there cannot be a uniform masculinization or feminization of the entire brain" (p. 381). That is, the conversation about sexual differences in brains is not over, as there are no conclusive arguments about it.

For their part, Joel et al. (2015), a behavioral neuroscientist, opts to understand that the human brain is on a continuum that goes from extreme femininity to extreme masculinity. There are no male and female brains, but rather proposes the idea of a 'mosaic brain', according to which all people have typical elements of one extreme and the other, and a great variety of intermediate elements between extremes. In fact, her proposal and that of her research group was initially published in 2015 under the title *Sex beyond the genitalia: The human brain mosaic*. That is, there is an impossibility of determining, in a closed binary way, two types of brains that correspond to genital binarism: "Our results demonstrate that regardless of the cause of the observed sex / gender differences in the brain and behavior (nature or nurture), human brains cannot be classified into two distinct classes: male brain / female brain" (Joel et al., 2015, p. 15468). In fact, from Joel's study, it is concluded that only between 0% and 8% of the brains in her study contain all the female elements or all the male elements. It is essential to note that compared to the small samples that are usually used, due to the very complexity of studying the human brain, in the research of Joel and his team, magnetic resonance imaging of 1,400 human brains was used. This information was crossed with analyzes of the personality, attitudes, interests, and behaviors of 5500 more people, to observe the structural sexual differences in the brain 'beyond the genitals'.

The evidence of the similarity between brains or the scarce difference found so far between 'women's brains' and 'men's brains', therefore does not allow us to bet on a separation based on that, or to advise segregation at school and in the classrooms. The neurologist Eliot (2011, 2013) has been particularly concerned not only with answering the arguments that affirm the sexual differentiation of brains, but with discrediting the proposal of segregation in the classrooms. Eliot (2011, 2013) refutes one



by one the theses on which the main arguments for the sexual differentiation of the brain are usually based. Attending to the three most popular:

- The size of the corpus callosum (which joins the two hemispheres). Despite the popular belief that it is more numerous in adolescent girls than in boys of the same age, the scientific community only recognizes as evidence that the size of the corpus callosum is related to the size of the entire brain and not to sex, as Eliot shows (2013).
- Brain lateralization, according to which the neural function of children is more lateralized; that is, boys use either the right or left side of the brain, one at a time, while girls use both hemispheres at the same time. The basis for this idea, which in reality is almost a myth, was a study by Shaywitz (1995), the conclusions of which were widely reported in the popular press. However, the scientific truth is that since that year an attempt has been made to replicate the experiment with a total of 1526 subjects studied (the original experiment used 38 subjects), and in all cases, it is concluded that the lateralization process is very complex, and that cannot be simplified by simplifying the difference between boys and girls. In fact, this simplification is now totally discredited, as explained by Sommert et al. (2008).
- The hormonal difference, and in relation to the nervous system and the hypothalamus, it has not been possible to conclusively prove that these differences are related to diverse and specific behaviors assigned to patterns of sex and gender, as documented by Eliot (2011).

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Reviewing the theses usually shared by those who base sexual difference in the brain as the foundation and argument to propose a segregated and differentiated education, it can be seen that, to this day, neuroscientific research cannot conclude such theses. However, they are still part of the social imaginary that influences beliefs about what is recommended for girls and boys when educating them. The scientific lies that have just been indicated as three of the main theses that maintain the idea of the sexual difference of the brain have been pointed out by eminent scientists as contaminants of the scientific process; such as Vidal (2012) and Fausto-Sterling (2000, 2015). Can it be said, then, that there is a science distorted by sexist culture?

Many scientists believe it and fight it. For example, those of the *Neurogenderings Network group* that has already been mentioned above.

And that is why it was said in the introduction to this article that tier work is a kind of ‘epistemological guerrilla’.

From the point of view that we are now interested in analyzing, there is the question of what philosophy of education can maintain. The neuroscientific foundation that proposes separating boys and girls in classrooms due to their brain differences has been discarded, due to being pseudoscientific or lack of evidence. But it is important to add that those preconceptions that are thought to be based on scientific authority are equally introduced into the classroom every day in a prejudicial way. That is to say, education today, even being in coeducation, recreates gender patterns that only social and cultural beliefs and constructions support.

In this article, it is proposed that before concluding with a philosophy with an educational proposal, we propose a model to understand from what framework this transdisciplinary dialogue is carried out, indicated above as necessary and urgent. With this objective, the proposal by Halpern (2012) and Miller and Halpern (2014) is very interesting. According to it, we need a biopsychosocial model of human life and cognition that does not fall within the dichotomous framework that thinks and studies sexual differences in terms of nature-culture. This framework, they point out, is very simple and deficient and prevents understanding human cognition in the complexity that it really presents. It has been seen how social changes in recent decades have improved the results that measure talent in specific areas: mathematics, language, orientation... All of this shows that cultural factors, like the growing reality of gender equality itself, can reverse sexual differences that were previously thought innate. This idea, linked to the quality of neuronal plasticity of the human being, allows a greater impact on the importance of agreeing in open and democratic processes what one wants to do with education and, ultimately, with the world.

Naturalizing the differences between collectives and human groups has been a common practice throughout human history. Science and its great development in the last two centuries allow us to search for innate explanations for these differences (which is a dangerous way that usually leads to inequalities). But, at a time in history when scientific collaboration, dialogue between the disciplines that generate knowledge and human awareness of the great planetary problems that exist, is more necessary than ever, the sciences cannot be made tools for ideologies to legitimize themselves, as Hartman (2012) or Malabou (2007) affirm. What philosophers of the Frankfurt School, such as Hartmann (2012), call ‘neurocapitalism’ refers precisely to the danger of depoliticization



that cognitive sciences that are not critical can suffer. Some sciences speak of ‘nature’ as an objective and neutral category. And this is not the case. Certainly, the biological is important because it is frequently taken to define social value; and, therefore, it becomes a mirror of political and social categories that will be decisive for living, surviving, and coexisting, as Malabou (2007) warns when he asks in the title of his book *What to do with our brain?*

The sciences in general, and the neurosciences in particular, have a function of legitimating certain powers and knowledge in the described capitalist context. That is, the pathologies of reason also have a point of inflection and pathological spread in scientific knowledge. The observation of brains, and the new techniques, can serve to legitimize and justify ‘scientifically’ certain policies, ideologies, norms and laws, and even myths and prejudices, as Fine (2017) and Rippon (2019) denounce. For this reason, the ‘reason’ of science not only does not save from the crisis of reason, but can make it worse.

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Conclusions

Popper (1983, p. 95) said: “We do not study issues, but problems; and the problems can cross the limits of any object of study or discipline. Well, what this article aims is the same, with the proposal of critical neurosciences, protected by a more open and democratic practice of science, a dialogue can be achieved that leads to a framework of transdisciplinarity.” This poses a great challenge for a theory and a praxis of education. Specifically, and due to the issue raised, it means abandoning the prejudices related to an idea as widespread in time as in the different geographies of the planet, and that is the categorization of the binary sexual difference of the brain.

In the transdisciplinary dialogue that is proposed here, neuroeducation appears as the sum of dialogues that can contribute, if they are critical, great progress for the enormous challenges posed today to the human species in charge of a planet and its destiny.

Faced with the impossibility of affirming the sexual differences in the brain, which some crave so much, it is proposed to optimistically embrace the theses of brain plasticity that are being revealed. Thus, the studies by Lipina (2016) and Lipina and Evers (2017) on the importance of living conditions for neurodevelopment are known. Specifically, their studies lead us to conclude how child poverty influences cognitive and

emotional development. These investigations lead to affirm that development in terms of rights, dignity, capacity, and social responsibilities has cognitive implications. What Gabrieli and Bunge (2016) called the stamp of poverty serves to understand the effect of the environment on the brain and on the development of intelligence throughout life; the opportunities and frustrations in parenting will be translated on a neurological level and in synaptic possibilities that will shape life. Pediatric studies confirm that there is a significant correlation between socio-economic status and many mental and brain functions, and even with the volume and structural details of certain areas of the brain important for cognitive and emotional functions, as stated by Johnson, Riis and Noble (2016). This brain plasticity, moreover, not only occurs during a stage of childhood life, but is maintained throughout life; not with the same intensity, but neural and synaptic plasticity remains throughout life.

This should bring optimism, since it implies the human capacity to become better, individually, in community, and as a species. The numerous scientific bibliography of recent years tells us how protection, good nutrition, care, ensure proper brain development. On the contrary, lack of protection, abuse, poverty, and the adverse socioeconomic environment in general, make it difficult and have an impact on the anatomy and function of the brain. As a consequence, there is a significant correlation between the socio-economic level and many mental and brain functions, and even with volume or structural details of areas of the brain important for cognitive and emotional functions, as studied by Johnson, Riis and Noble (2016).

All this speaks of how fundamental brain plasticity can be to understand education as an element of impactful social transformations, as stated by May (2011). Of course, eliminating gender inequalities could improve the academic results of all, women and men; as stated in their research by Miyake et al. (2010), Hartley and Sutton (2013), and Weber et al. (2014). Understanding the importance of this capacity for action should lead us to be aware of the great impact that educational policies can have. For this reason, we also need a better way of relating educational policies to scientific research policies. The proposal of this article is that the educational debate advances in understanding how from coeducation, and detaching itself from gender patterns of differences and inequalities, a framework of equality can be promoted that enables cooperative learning and diversity. This diversity in classrooms is an element that can help, more than homogeneity, to promote learning, as Cin (2017) explains. From this philosophy of education, the reflection about whether a



segregated education or coeducation is preferable does not depend on whether sexual differences are found in the brain; ultimately, it is not scientific findings that determine what and how to educate. It is clear that cognitive differences exist, but not so much between groups, but between individuals, as Joel et al. (2015) demonstrated and recently also Rippon (2019). But this can never be an argument to advise group separation in the teaching-learning process.

It is true that there are no conclusions from the neurosciences that endorse that educational results are better in coeducation or in segregated classes. But there are robust conclusions about the importance of starting with gender equality policies to improve the educational results of young people. Numerous studies support it, such as Guiso et al. (2008), Corbett and Hill (2008), Klein (2007), Fassa, Rolle, and Storari (2014), Fassa (2016), van Hek, Kraaykamp and Pelzer (2017). That these equality policies are more possible to implement in a coeducational school, it is something that experience does demonstrate, as confirmed by Chaluda (2017), or by UNESCO (2015). In conclusion, it is necessary to emphasize some clear ideas from the research presented here: the need to think about science and the generation of knowledge in another way; the urgency to get rid of pseudoscientific arguments (very specifically in relation to sexual difference in the brain) when thinking about education as the most vital element in human life; the requirement to conceive the human brain as having a quality of plasticity and continuous learning; and, finally, learn, organize and agree on all of this so that education is primarily a path that helps train people as agents of social transformation for a more just and egalitarian world.

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