Soft Computing Confronting Philosophical and Sociological Critiques to Classical AI

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Abstract— *Artificial Intelligence has been one of the fields within Computer Science that has generated more interest and debates among philosophers. Later on, the most recent field of Science and Technology Studies (STS) also has shown some interest in AI. In both cases most of the authors have been quite critical about the promises, the practices and particularly the epistemological basis of Classical AI. The first part of the paper consists on an enumeration of the most important authors and their critiques to AI in Philosophy and STS studies. Since Soft Computing implies important changes with respect to traditional AI approaches like Symbolic AI, the second part of the paper will be devoted to confront Soft Computing with the critiques and challenges and to weight up to what extent Soft Computing could (or could not) answer differently than other AI approaches regarding the critiques received.*

Keywords— Epistemology, Philosophical critiques to AI, Science and Technology Studies (STS), Soft Computing.

1 Introduction

Since its origins Artificial Intelligence has been one of the fields within Computer Science that has generated more interest and debates among philosophers and cognitive scientists. Not in vain, Artificial Intelligence deals with some of the traditionally most debated issues in philosophy such as knowledge and reasoning. In concrete, some of the ambitious statements of the first AI researchers touch very sensitive "fibers" of philosophers. Authors like John Searle, Daniel Dennett, Hubert Dreyfus or Roger Penrose were among the first ones to cope with these issues [1, 2, 3, 4, 5].

The philosophical debate during the 1970s and 80s focused on Artificial Intelligence via Symbolic AI (the branch of artificial intelligence research that concerns itself with attempting to explicitly represent human knowledge in a declarative form -i.e. facts and rules-), since this was the approach followed by the main scientists in the field from the early days on. The main interest of philosophers has been traditionally centred in the question about whether computers can or cannot think, which generally implies doing it "in the sense humans do". There was an assumption among philosophers (though induced by claims made by some of the first AI researches) that the aim of AI is to create "an artificial mind". Despite the successes of some AI symbolic systems during the 60s, the enormous promises of early AI texts posed the debate in terms of the possible success or failure of the whole enterprise of creating an artificial mind.

Because of that the discussion was pursued in a very bi-polar manner with some philosophers (like Dennett) clearly optimistic about the question and others (like Searle and Dreyfus) very critical about it. The philosophical critique was in tune with a significant resistance in general culture, which tried to assure the specificity of human nature with regard to computational artifacts, often appealing to non-cognitive aspects of the mind (intentionality, emotion, perception, etc).

2 Philosophical Critiques

2.1 Turing

The British mathematician Alan Turing was not only the one who set the basic elements of computation, but also the one who posed the first stone of this debate about the possibility of "thinking machines", proposing a mental experiment known, since then, as the "Turing test" [6]. It consists on an interrogator asking questions (through a separating barrier) to a machine and a human, trying to guess who (which) is answering. If the interrogator cannot tell whether the responder is the human or the machine, then the intelligence of the machine would be proved.

The interest of Turing's idea lies on the practical way he is proposing the test as an "imitation game". He is not defining, at least *a priori*, what intelligence *is* but establishing a practice were the performance of human intelligence is showed. Whether the machine thinks "in the way humans do" or not is not addressed by the Turing's test. In fact, it is precisely this kind of philosophical question what he tries to avoid.

2.2 Searle

In his famous paper from 1980 [1] the American philosopher John Searle argued against the strong claim that computers can be intelligent *in the same way* humans are, which for him implies having cognitive or psychological states (i.e. conscious understanding and intentionality). He distinguishes two strands of AI. The former claim is called "Strong AI": intelligent machines would replicate not only intelligent *products,* but the intelligent *process*[1]. By contrast, "Weak AI" is the perspective that understand computers as useful tools that mimic some of the abilities and tasks of humans (included those that are considered intelligent), in part because they can simulate "smart actions"[2]. Weak AI does not make the claim that computers *actually understand* or *have* mental states.

Searle's critique is directed to Strong AI. To do that, he proposes a thought experiment known as "The Chinese room" in response to Alan Turing's suggestion to replace the question "Can machines think?" with the question of whether

ISBN: 978-989-95079-6-8

they can succeed in an "imitation game". In short, Searle's conclusion is that a native English speaker who knows no Chinese together with a book of instructions for manipulating the symbols would able to pass out Chinese symbols which are correct answers to the questions. The instructions enable him/her to pass the Turing Test but he does not understand a word of Chinese[3].

The axis of the argument relies also on the idea that *syntactic manipulation* (formal symbol manipulation or computation) does not imply understanding *semantics* (understanding of meanings). For Searle, we can not attribute intelligence to such a system since "real intelligence" is related with understanding. The background argument of the Chinese room is that one of the main features of human minds is intentionality (which is a mental state) and that is something that computers do not (and can not) have.

2.3 Dennet

Though many of the philosophers of AI have been very critical, Daniel Dennett is an exception [2]. He shared with Symbolic AI researchers what in philosophy of mind and cognitive sciences is called the "Computational (and Representational) Theory of Mind". Dennett has been positively linked to AI and he has participated in some AI projects. He disagrees with Searle in two important points:

a) The way that Searle understands intentionality is already assumed from the beginning as limited to humans. Against that, Dennett affirms that human consciousness and intentionality are not as specific as we use to think, which is showed in the way we use a "mentalist language" when describing the actions of animals, machines and so on.

b) The Chinese Room thought experiment is very ingenious but is very far from actual practices in everyday life. It involves a number of things that are quite impossible to do so it is very doubtful to be used as a proof of something[4].

2.4 Dreyfus

However, the philosopher who most energy and time has devoted to the critique of AI during the past 30 years has been the phenomenologist Hubert Dreyfus [3, 4]. Drawing upon Heidegger and existential phenomenology, his arguments are quite different from Searle's (though he also affirms that neither current machines nor future ones would be intelligent).

Dreyfus criticizes the epistemological assumption of Symbolic AI that all activity can be formalized in the form of propositional knowledge (which would allow computation in the form of "rule-based symbol manipulation") as it is done in many Symbolic AI based expert systems. For Dreyfus, many parts of human knowledge and competences cannot be reduced to an algorithmic procedure, i.e. the kind of knowledge one might employ when learning a skill like walking, riding a bike or ice skating. This learning is done through practice with our bodies: to learn how to do it one must get on and try it, it's not enough to follow written rules. This requires having a body and experimenting with it in a changing environment.

Though Dreyfus concedes that certain well-circumscribed experts systems for particular domains have succeeded, he predicts that many others will never fulfil the expectations (i.e. Lenat y Guha's "Cyc" [7]). This is not because of technical shortages (that could be overcome in the future) but because symbolic type of artificial systems are incapable of representing bodily-skills knowledge, which can not be captured in an algorithm.

3 Soft Computing confronting Philosophical Critiques

3.1 Not related to Strong AI

The problem with Searle's thought experiment is that most of practitioners in AI do not take issue with intentionality or creating an artificial mind. This debate is in fact a philosophical one (the old debate between Behaviorism and Mentalism[5]) and is far from the interests of Soft Computing (SC) practitioners, as far as I could observe. Although this debate was in part provoked by the excessively optimistic predictions of some of the founding fathers of AI, it can be said that the SC community is more focused on solving concrete problems by constructing machines that can perform "intelligent" tasks, which is more in tone with what Searle called "Weak AI". Because of that, these kind philosophical critiques do not apply to Soft Computing.

However in one of his last articles, Zadeh says that there is a possibility of achieving "human-level machine intelligence", though for that there is needed a paradigm shift [8].

3.2 Necesity of Semantics

The other axis of Searle's critique relied on the idea that *syntax* (formal symbol manipulation or computation) does not imply *semantics* (understand meanings). Searle applied it to say that, to have "real intelligence", syntax is not enough. One of the fundaments of Fuzzy Logic is precisely to deal with meaning in natural language. Fuzzy Logic agrees with Wittgenstein's definition of meaning as its use in language [9], that is, as used by concrete people in concrete contexts.

To model and operate with natural language and its non-static meanings would require tools which can deal with imprecision and uncertainty, which is precisely the main characteristic of Fuzzy Logic. The enormous importance of natural language for SC is shown in the turn Zadeh proposed in 1996 saying that Fuzzy Logic was equivalent to "Computing with Words*"* [10]. Computing with words (CW), Zadeh says, is a methodology in which words are used in place of numbers for computing and reasoning. As fuzzy sets are able to model some natural language's concepts, it would be possible to use these models to compute directly with them.

3.3 The "Bodily-skills knowledge" Problem

Dreyfus's main critique to symbolic type of artificial systems is its incapability of representing bodily-skills knowledge. Other types of AI systems have tried to avoid this problem, like Rodney Brooks' "bottom-up" strategies in *embedded* or *situated robotics* [11]. The work of Brooks and his colleagues focus on *embodiment,* the idea that intelligent behaviour is an *emergent* phenomenon resulting from the

ISBN: 978-989-95079-6-8

individual's interactions with its environment, which are more related to action than to representation.
What Soft Computing has to say about this debate? In general we could say not much. The problem of embodiment is typical in Robotics (where there are "embodied machines", not only software) but not necessarily in most of the branches of AI. Fuzzy Logic indeed deals with language and representation of meanings and not so much with actions. However, applications of Fuzzy Logic to concrete systems (fuzzy control) do actually deal with systems-in-action. One clear example is the "inverted pendulum" solved by Yamakawa [12] using a small set of simple fuzzy rules. Fuzzy control system design is based on empirical methods, basically an approach of trial-and-error, which is quite related to the way humans learn bodily-skills knowledge.

4 STS Critiques

Among the different non-technical disciplines not only philosophy has been interested in the study of AI. Within the so-called area of STS, at least some practitioners have turn around to Artificial Intelligence.
An STS methodology implies the analysis of the social and cultural contexts where all scientific and technological developments take part. This model resists classical accounts that science and technology are totally objective and neutral with respect to the context where they are made.
Regarding AI, STS takes a different stand on that philosophical critique. They don't take part in abstract discussions about the ultimate goal of AI. Their methodology consists on looking at real practices, including ethnographic observation of AI practitioners. From the STS view, the important thing is the way these engineers understand and use (or model) concepts such as knowledge and reasoning in their daily practice.

4.1 Harry Collins

Harry Collins' study of AI [13] is the most important contribution from part of STS to the study of AI. The field of Experts Systems has attracted the most attention from part of social scientists. His critique is in a way quite similar to Dreyfus' regarding the impossibility of formalizing certain types of knowledge.
Based on recent Sociology of Scientific Knowledge [14] and Laboratory Studies [15], in which is shown how experimenters need to share a culture in order to produce science, Collins maintains that skills (know-how knowledge) are principally acquired through enculturation and the acquisition of tacit capacities whose transmission is implicit (and cannot, therefore, fully be spelt out in formal algorithms). This kind of knowledge it is commonly known in STS as "tacit knowledge", which can be also understood as the "common knowledge" of a particular community (what is taken for granted within it)[6].
However, Collins understands "tacit knowledge" more widely than Dreyfus' embodied knowledge. Acquisition of skills-type knowledge in his view is related to socialization rather than embodiment. The underlying argument of Collins against Dreyfus is the importance of natural language. Collins affirms that one can learn to speak fluently about the world without being bodily involved in it. This model assumes that socialization (in a certain group) is necessary to communicate knowledge. In this way, Collins brings the discussion to the cultural arena
Another of the issues addressed by Collins is his focus on AI systems that are already being used and seem like functioning, not in possible future ones. The challenge is, then, to explain that "success". On the contrary of philosopher's understanding of computers as artificial brains, to him the role (and success) of AI is to create "social prostheses". And it is the ability of humans to interpret their actions and repairing their deficiencies which makes them successful. In a way, humans interpret machines actions as one kind of actions humans can perform (what Collins calls "machine-like action"), but this is only a little part of the whole kind of humans' actions. This human ability to interpret and repair normally remains invisible, but, for Collins, is here where the intelligence attributed to machines rests on.

4.2 Diana Forshyte

The work of Diana Forsythe [16] belongs to the field of Anthropology of Science[7] rooted in cultural anthropology's tradition. This normally implies a more or less long-term field research using the ethnographic method of participant observation. In her ethnographic study of an Expert Systems community in the US, she investigated what she called the "Culture of the Experts Systems Engineers", defined as the values and assumptions (explicit but mostly implicit) that constitute what they take for granted. Forshyte also refers to this as "common sense truths", which are those things 'everybody knows' within a given setting (this shared and tacit knowledge is indeed the main criterion to be considered a member of the community). The importance of the ethnographic method relies on the main thesis of cultural anthropology about the complex relation between beliefs and practices: usually what people do, what they think they do, and what they report they do are someway different.
Investigating the culture of the Expert Systems practitioners she found they share a particular notion of knowledge (a very restricted one), that has important implications for the products they make. Their epistemological stances are very important because they are going to be incorporated (encoded) into the expert systems produced. To prove this she focused on the first step of the process of building an expert system: 'knowledge acquisition' (also known as elicitation process), consisting in the "extraction" of the knowledge from human experts. The very use of the terms "extraction" and others such "store" (knowledge is presumed to be "stored" in the head of the experts) are metaphors which implies an understanding of knowledge as objective and susceptible of being formally transferred into a machine.
Despite that, the elicitation process is considered by knowledge engineers themselves a very persistent problem and is thought to be the cause of failures in the systems when encountering 'real-world situations' (situations that the systems builders did not anticipate). Knowledge engineers blame human experts interviewed for not being able to explicit clearly their expert knowledge, that is, in the way they can encode it (it is not casual that the kind of expert

ISBN: 978-989-95079-6-8

knowledge they prefer to work with are already those very formalized in well-defined narrow domains).
They would never think about the possibility that their implicit assumptions about knowledge can be the cause of their problems. Forshyte affirms that the knowledge encoded in experts systems is static, brittle and narrow, while in real life knowledge is continuously modified in relation to contextual factors and trough negotiations between different actors, and that is the real cause of the 'brittleness' of the systems[8].
In general terms, the kind of expert systems studied by Forshyte are included in the more general approach of Symbolic AI, since, in the end, knowledge "extracted" from human experts has to be written-down in rules-type propositional knowledge. With respect to this, the same critique from Dreyfus and Collins about the inability to model other types of knowledge (particularly social knowledge) is applicable relating Forshyte's work.

4.3 Alison Adam

One tradition within STS studies are those investigating the relations of gender factors with science and technology[9]. Notions of gender are constructed not only in relation to economy or moral values but also science and technology became in our culture more associated with the masculine than the feminine, reflecting cultural's view of what constitutes masculine or feminine. However this is not a fixed but a historical process[10].
Alison Adam is a British computer scientist and feminist who has pursued the most extended study about gender and Artificial Intelligence [17]. She accurately applies the insights of feminist epistemology (an alternative kind of epistemology which criticizes the classical conservative epistemologically) to the main traditions in AI as Symbolic AI, Expert Systems, and also more recent approaches such as Artificial Life and Situated Robotics. Adam's work is devoted to "uncover" the implicit (gendered) epistemological assumptions in AI, because on them depend how AI researchers understand some key concepts which very much influence their work such 'intelligence', 'knowledge', 'reasoning' and 'efficiency'. The idea, then, is not to look for the contributions of individual women in the history of AI, but rather to look if there can be gendered models of knowledge implicit in AI systems.
One of Adam's theses is that traditional AI systems are based on the Cartesian ideal of a disembodied mind and the over-valuation of mental (abstract) knowledge over corporeal (concrete) knowledge; the former has been historically associated with masculine realm while the latter has been largely associated with the feminine. For Adam as for other feminist epistemologists [18, 19], this is very much related to the "mathematization" of the Western Culture (started in ancient Greece and increased in the Modern Age) and the idea that the entire universe was governed by numbers. Although there was already among the Greeks a plea for other ways of knowing it, was this Platonic and then Aristotelian conception of the world which finally succeeded. Aristotle is considered "the father of Logic", and defines the correct way of reasoning in terms of a dichotomous logic (there are only true or false statements which imply only valid or invalid inferences). As we know, the rejection of this thesis was the starting point of Zadeh's Fuzzy Logic.
Following the work of the philosopher Lorrain Code [20], Adam shows that traditional AI is based on the rationalistic epistemological model of "S knows that p". 'S' refers to the knowledge subject (*who knows*), and 'p' the object of that knowledge (w*hat can be known*).
Regarding 'p', as we already said, propositional knowing (or *knowing that)* is considered to be superior knowledge while others (skill-knowledge or *knowing how*) are less important. Feminist epistemologies consider this stratification as an *epistemic discrimination* (which they affirm is not innocent of gender factors).
Regarding 'S', the ideal knower of Classical AI is an anonymous, universal and "knowing from nowhere" subject[11]. On the contrary, Adam emphasizes the "situatedness" of the knower. For example, who are the "knowledge subjects" of systems like "Cyc"? This project leaded by Douglas Lenat [7] tries to build a vast knowledge base which will include most of human common-sense knowledge. Above all, Lenat assumes that there is one *and only one* consensus reality available common to all humans. The development of STS and Anthropology is the last decades have shown that it is quite problematic to assume that hypothesis. We "see" the world according to our theories of the world, and these theories depend on our cultural location. At bottom, what CYC knowledge base would consist on is what Adam's calls "*The-World-As-The-Builders-Of-Cyc-Believe-It-To-Be",* who are a group of predominantly middle-class male US university professors, that, without realizing it or intending it, are privileging their "consensus reality" over other groups' [17].
As a way of summarizing the differences between the two kind of epistemologies we can make the following table:

Table 1: Contrasting Epistemologies

Symbolic AI Epistemology	**STS Epistemology**
Objective Knowledge *(context free, universal)*	Situated Knowledge *(contextual, local)*
Propositional knowing (*knowing that*)	Skills-type and Common-sense Knowledge
Abstract reasoning	Concrete reasoning
Epistemological Monism	Epistemological Pluralism
Lack of Reflexivity	Accountability and Responsibility

5 Soft Computing confronting STS Critiques

5.1 Contextualism

As we said before, workers in the field of Symbolic AI claim that cognition is the manipulation of internal symbols by logical rules, so, therefore, human knowledge is, to a large extent, *context free*. We have explained how this idea has been criticized by authors like Dreyfus or Collins.
Wittgenstein's pragmatist turn in *The Philosophical Investigations*, which is assumed by SC, implies that meaning can only be grasped when used by concrete people

ISBN: 978-989-95079-6-8

in concrete contexts. The philosopher, Wittgenstein says, must "look and see" the variety of uses to which the word is put in particular cases. In this way, previous empirical analysis of the context of use it is an obligatory step for SC developments.
This obligates SC to be an e*mpirically-based research,* not only a theoretical approach (this is also because the ultimate goal of SC is engineering, that is, constructing machines, which in the end has to be used by users).
In spite that the idea of contextualism may be implicit in SC practitioners, the problem about the "situatedness" of the knowledge subject regarding the difference or culture, class, nation, race or gender has not been addressed as such neither in theory nor in specific projects, as far as I know.

5.2 The "Common-sense knowledge" Problem

As we have seen, the apelation to the inability of Classical AI to deal with common-sense knowledge is an important part of STS critiques. Their argument is that this kind of knowledge is mostly tacit and took for granted, and, because of that, it can not be formalized.
On the contrary, many SC articles contain the affirmation that fuzzy logic could represent common-sense knowledge. The most explicit article from Zadeh about the topic [21] explain that common-sense knowledge is expressed in *dispositions*, as opposed to propositions. A disposition in philosophy is a kind of belief that is stored in the mind but is not currently being considered (in a way we can say is a kind of tacit knowledge). For the purpose of representation Zadeh defines a disposition as a proposition with implicit fuzzy quantifiers, so in that way fuzzy logic can be used to deal with that kind of knowledge.
Although this strategy is only in its first steps, I think is a very promising way of dealing with common-sense knowledge, at least much better than Guha and Leant kind of propositional knowledge data base. However, there are many issues that are not addressed or solved yet in SC. A very important one has to do with the very definition of "common-sense knowledge" and its interrelations with concepts as "tacit knowledge", "skill-knowledge", "situated knowledge" and so on. Is it all common-sense knowledge tacit or just "taken for granted"? The difference between common-sense and skill-knowledge is that one can be formulated in *dispositions* and the other one not? What Zadeh exactly means when he talks about "world knowledge" –defined as "the knowledge humans acquire though experience, communication and education"?

5.3 Pluralism and Hybridization

Though we have not explicitly say it before, one of the main proposals from STS and feminist epistemologies is the appeal to alternative ways of knowing and doing science. Lucy Suchman, regarding computer science, talks about **"**expanding the frame of basic modeling assumptions" [22], which means expanding the very foundational paradigms of the discipline (particularly its assumptions about knowledge) and introduce alternative paradigms. This, regarding theory of knowledge, is what is called *Epistemological Pluralism*.
I think SC can be a little bit closer to these suggestions than other approaches. On one hand the basic characteristic of SC is precisely the combination of methods. Quoting Zadeh: *"SC is not a single methodology; rather is a consortium of methodologies which are aimed at exploiting the tolerance for imprecision (...) The constituent methodologies in SC are for the most part complementary and synergistic rather than competitive* [22]*".* So we can say pluralism and hybridization are at the very core of what SC is, but… do they mean with that the same as STS scholars when they mention it?
This question leads us to the following point.

5.4 Issues of Accountability and Responsibility

Pluralism in STS and feminist epistemology is related to issues of accountability and responsibility, which means that the ultimate goal is to introduce (some) changes in science and technology to make them more inclusive and socially just. Authors as Lucy Suchman [23] and Philip Agre [24] whose work is devoted to Artificial Intelligence, appeal to epistemological and methodological pluralism as a way of accommodating diversity. Agre calls this possible way of doing technology a *critical technical practice*, which consists on identifying core metaphors of the field, noticing what (when working with these metaphors) is marginalized, and inverting dominant metaphors bringing alternative perspectives from the margins of the discipline to the center.
As far as I could observe, Soft Computing practitioners have not introduce the issues of accountability and responsibility explicitly in their practice (on the other hand like most part of computer science and technology except but some particular approaches in software engineering like participatory design or user-centred design). However my suggestion is that, because of some particular characteristics (that we already pointed out), Soft Computing is more suitable to include this issues than other more abstract approaches such, for example, Symbolic AI.

6 Conclusion Remarks

Along the article I have enumerated various critiques made to traditional approaches in Artificial Intelligence from part of Philosophy and, later, from Science and Technology Studies. Soft Computing distinguishes itself very much from traditional AI approaches. Because of that, it appears to me as a very interesting topic to question how Soft Computing could cope with these critiques and challenges.
Although this research is still in a preliminary state, I think the issues treated in this article can provide a good frame for future work in the new field of Soft Computing in Humanities and Social Sciences. In addition to that, it could be also of some use for Soft Computing itself. Soft Computing have to face many challenges in order to improve other AI methodologies and try to achieve what they weren't able to. Having a clear picture of these challenges will be very useful. Philosophical and sociological studies of science could help to identify problems and challenges, and, although far from engineering practice, can inspire and suggest new ways of facing the most durable challenges.

ISBN: 978-989-95079-6-8

Acknowledgments

The author wants to thank Sergio Guadarrama for his comments and fruitful discussions about the topic of the paper.

In addition, I want to thank the Foundation for the Advancement of Soft Computing for providing me the best place and environment to proceed with my research in this topic.

[1] Strong AI is would be, then, the materialization of the "Computational Theory of Mind" (the philosophical view that holds that the mind is *literally* a digital computer and reasoning consists on formal manipulations of symbolic representations of the world). Through this thesis the debate became not only a philosophical one but also a psychological one: it provides a working model of human intelligence.

[2] In fact this is in tune with the most quoted definition of AI: *"AI is the ability of a computer or other machine to perform those activities that are normally thought to require intelligence"* [25]

[3] For a detailed description see *Stanford Encyclopedia of Philosophy's* entry "The Chinese Room Argument".

[4] Actually Dennett elaborated this critique in general against all kind of "thought experiments".

[5] That is, whether or not there are "internal mental states" in the mind that can be studied by psychologists, or only observable behavior.

[6] Very much related with a very important concept in STS known as "epistemic cultures"

[7] The pioneers of the application of Anthropology to the study of science are the so-called laboratory studies of Latour and Woolgar [15], Karin Knorr-Cetina, and Michael Lynch.

[8] As an anthropologist whose background understanding about knowledge is precisely the opposite (in Social Sciences knowledge is a highly problematic issue, mostly tacit and unconscious and whose "locus" is the a social group or community) is very shocking to confront herself with such a different approach.

[9] We should explain here what we mean with "gender" in gender studies. It is not about the gender of the particular individuals involved in science and technology (particular men or women) not even men and women in general, but the gender systems (defined as gender structures, gender identities and gender symbolisms) in which these science and technology is developed (in our case Western gender system), and how this system influence its process, for example gendered models of knowledge, which is the main topic of the so-called Feminist Epistemology.

[10] However there is no intrinsic reason why a technology may become associated with the masculine or the feminine gender, this may change over time. It is precisely in the contingence of this process where feminism locates its hope in change towards a more egalitarian relation between women and technology.

[11] This epistemology considers logic as the paradigm of valid knowledge. Logic characterizes precisely by depersonalizing the subject and being the paradigm of context-free knowledge.

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