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„Simone Weil’s Philosophy of Science“

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Abstract (English):

In this master's thesis, I will discuss Simone Weil's philosophy of science. In the existing literature, Weil is mostly discussed with regards to her practical philosophy. However, her early writings also provide, as I intend to show, interesting perspectives on science. On the one hand, she discusses recent developments in light of their historical evolution, such as the rise of non-Euclidean geometry in mathematics, the theory of relativity, and quantum mechanics. On the other, she connects them to more general philosophical views on epistemological and metaphysical issues in mathematics and physics, as well as the philosophy of mind. Finally, Weil offers an own account on the role and function of science in society with a focus on education. The overall aim of the thesis is, on the one hand, to make more accessible Weil's idiosyncratic thinking to analytic philosophers by reconstructing her main arguments and discussing them in light of literature on the historical issues at stake. On the other, I intend to shed new light on some of Weil's own ideas and discuss them with regards to current philosophical debates.

Abstract (German):

In dieser Masterarbeit werde ich die Wissenschaftsphilosophie und Wissenschaftskritik von Simone Weil diskutieren. In der vorhandenen Literatur wird Weil vor allem im Hinblick auf ihre praktische Philosophie diskutiert. Insbesondere ihre frühen Schriften bieten jedoch, wie ich zeigen möchte, auch interessante Perspektiven auf Wissenschaft. Einerseits diskutiert Weil zeitgenössische Entwicklungen im Lichte ihrer historischen Evolution, wie etwa das Aufkommen der nicht-euklidischen Geometrie und des Konventionalismus in der Mathematik, Einsteins Relativitätstheorie und Quantenmechanik. Zum anderen stellt sie eine Verbindung zu allgemeineren philosophischen Ansichten über erkenntnistheoretische und metaphysische Fragen in der Mathematik und Physik sowie der Philosophie des Geistes her. Schließlich verteidigt Weil eine eigene Position hinsichtlich der Rolle und Funktion der Wissenschaft in der Gesellschaft mit einem Schwerpunkt auf Bildung. Das Ziel der Arbeit besteht einerseits darin, analytischen Philosophen Weils idiosynkratisches Denken näher zu bringen, indem ich ihre Hauptargumente rekonstruiere und im Lichte relevanter Literatur kritisch diskutiere. Zum anderen möchte ich auf Weils eigene Position aufmerksam machen und einige Aspekte mit Bezug auf aktuelle philosophische Debatten diskutieren.

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Introduction

In this Master's thesis, I will discuss Simone Weil's philosophy of science. Weil was not only a philosopher, but she was also a political activist. Writing in the nineteen twenties, she not only witnessed ground-breaking scientific discoveries and the so-called "second birth" of mathematics, but also faced the social grievances of the French industrial revolution and the political impotence of the interwar years. Her philosophy and critique of science is a product of her engagement with contemporary science as a philosopher and her political activism.

The overall aim of the thesis is, on the one hand, to make more accessible Weil's idiosyncratic thinking to analytic philosophers by reconstructing her main arguments and discussing them in light of literature on the historical issues at stake. On the other, I intend to shed new light on so far underrepresented philosophical concerns about science as presented by Weil.

In the literature, Weil is mostly discussed with regards to her political thought and her philosophy of religion. However, especially in her early writings, Weil also provides also, as I intend to show, interesting perspectives on science. On the one hand, she offers a critique of contemporary science, that is science in the early twentieth century with a focus on the French context. Here, she discusses a handful of recent developments in light of their historical evolution, such as the rise of non-Euclidean geometry in mathematics, the theory of relativity and quantum mechanics, and the axiomatic method. Her approach here is mostly historical. On the other, she defends more general philosophical views on science. Here, she addresses metaphysical and epistemological issues in mathematics and physics, such as the role of experience and intuition in geometry, logical empiricism and formalism, ontic realism, and conventionalism in mathematics as defended, e.g., by Henri Poincaré.

Both in her critique and her own account, Weil addresses science in two different ways: For one thing, she criticises and defends certain approaches in terms of the *idea of science* they imply. Here, science is addresses as knowledge-seeking activity as such and how it connects, for instance, to our mind and perception. For another, she discusses *science as a social institution* with its own culture, relationships, interest, and attitudes. Here, she addresses the scientific community as a political player in its relations to education, the industry and economy.

Now, how are these ideas connected to her analysis of recent developments in science? To cut a long story short: Weil does not criticize certain theories *per se*, in the sense of an internal criticism that seeks to point out incoherences or flaws that make them empirically or logically "faulty". Her critique is rather a "critique from outside", reflecting on more general consequences that these developments entail with regards to how they alter science's role in society and the relationship between "scientific thought" and "ordinary thought", between scientists and ordinary people as 'knowing agents'. When discussing science's role in society, Weil is particularly interested in certain attitudes and beliefs displayed by the scientific community, like the "science for science's sake" movement, epistocratic ideas about education and politics and application-centred approaches that seek, in Weil's view, to "capitalise science".

Down to these points of criticism is, on the one hand, Weil's Enlightenment-inspired understanding of science and education as means of escape from states of political immaturity and intellectual subjugation. One the other, it draws on her anthropological idea of humans as self-conscious beings with a strong need for understanding of the world surrounding them in order to make sense of their own experiences and become self-determined agents.

In the first chapter, I give a short outline of Weil's main point of criticism and her understanding of science and education more generally. I will start with summarising Weil's critique under two main points to which I will refer by (I) Science's disconnection from reality (Chapter 2) and (II) Science's disconnection from society (Chapter 3). Then, I will comment on the partly historical, and partly universalist approach of her critique. Here, I will argue that Weil's understanding of mathematics and physics is best addressed on different levels: her understanding of the subjects of mathematics and physics, her understanding of Mathematics and Physics as academic disciplines at her time, and her understanding of science more generally. On all three levels we meet descriptive and normative elements. I will refer back to them when reconstructing her arguments. On the third layer – her understanding of science more generally – I will say a few preliminary words in the last subchapter of this section. The issue will be taken up once more and at length in the third chapter.

In the second chapter, I will reconstruct and critically discuss Weil's arguments summarised above under the first point of criticism: "science's disconnection from reality". In the end of the nineteenth and early twentieth century, Weil sees the understanding of "truth" and "knowledge" in science undergo fundamental change. Anti-realist stances in mathematics and logical empiricism in the natural sciences challenge and alter prevailing philosophical –

rationalist – understandings of science. Furthermore, recent developments such as non-Euclidean geometry, the theory of relativity, and quantum mechanics revise considerable parts of the hitherto upheld body of knowledge, they also move science further away from human life-world experience. More concretely, Weil claims that theories' truth value is nowadays grounded rather in the consistence of models than in what we ordinarily perceive as "nature" or "reality" (perception, common beliefs). Images of reality created by science are very abstract and often not anymore connectable to what she calls "ordinary thought". In this way, scientific knowledge is no longer a more elaborated version of ordinary knowledge, but a sort of "alternative narrative" which claims to be "true knowledge", and distinct from "common – unjustified – belief". This incommensurability of scientific thought and ordinary thought entails, in Weil's eyes, further negative consequences: One is the objectification (and as a consequence, alienation) of life-world experience by means of technical instruments and abstract concepts: When reality is reduced to the scientifically measurable, this entails also a radical selection of what counts as reality worth observing. For instance, concepts which stem originally from the life-world and ordinary language are being imported into science (like "work" in physics). Initially as an analogy still relying in its meaning on the real-world phenomenon, it then became an independent abstract concept that, in the long term, seizes and alternates the meaning of our common-sense notions. We then tend to forget that work involves, other than force (effort) and displacement, also things such as hope, aspiration and suffering. According to Weil, this leads to an alienation from the life-world and an indifference towards human needs.

In the third and final chapter, I will turn to Weil's arguments which I summarised under the label "science's disconnection from society". While the second chapter deals with the way Weil addresses science in terms of scientific theories and concepts, I will now turn to her account on science as an institution in society and scientists as a group of moral agents with certain aspirations and attitudes. This connects her observations about science as an apparatus of knowledge production to her critique of science as an institution in society, as well as scientists as moral agents. In her understanding, scientists are not merely a group of intellectuals who pursue their particular interests in a certain field of knowledge, but also socio-political agents who actively shape the future and development of life in society. As such, and besides their inner-scientific aspirations, they should aspire towards two main educational goals: they should seek to help people make sense of their experiences and they should strive against social injustice based on educational inequalities.

Here, I will outline Weil's criticism of the "science for science's sake attitude" (SfSS), as defended by Poincaré. For one thing, Weil argues that it is incompatible with pragmatic approaches of justification, such as conventionalism. For another, she disagrees with it in essential, even though not in all points. First, I will reconstruct Poincaré's SfSS remarks under two main lines of argumentation: that science should be done by scientists without external interference, and how this is better for everyone. Second, I will discuss Weil's views on the science-society relationship with a special emphasis on the point raised by Poincaré. I will show that they share the basic belief that science has intrinsic value, and that freedom of scientific research is worth protecting. However, Weil, unlike Poincaré, differentiates between science as the activity of knowledge-seeking and science as a publicly funded social institution. While Poincaré argues that science intrinsically promotes morality, Weil thinks that the scientific community has responsibilities towards society (e.g., in the context of education) and certain constraints are therefore justified. Furthermore, they see this freedom threatened by different kinds of external influence. Poincaré seeks to defend science mainly against political influence. Weil's main preoccupation is with the influence of the industry and capitalist economies. Scientific knowledge production displays, in her eyes, alarming similarities with the industrial production of goods.

Then, I will move on to discussing Weil's ideas about intellectual progress and individual knowledge and how she sees them connected to freedom and self-determination. Here, Weil takes up the claim that SfSS is justified by the 'progress' it entails on the pragmatical (technological and economic) level. She argues that this view on progress is one-sided and positivistic and points to the fact that scientific discoveries do not necessarily lead to improvements, e.g., in living conditions or social justice, but can also have the opposite effect. She also questions the concept of "scientific progress" understood as the accumulation of knowledge since it largely relies on specialist culture and division of labour and yields a rather insular than holistic understanding on the individual level. Weil then applies her ideas about education, self-determination, and freedom to her phenomenological observations of living conditions of factory workers. Workers suffer, in her eyes, oppression in a double sense: On the one hand, they are exposed to inhuman working conditions which make them experience themselves as cogs in the wheel of the machine. On the other hand, the separation of manual and intellectual labour leaves them in a state of unconscious ignorance where they are neither able to make sense of the work processes of which they are part, nor of the misery induced by the working conditions.

Finally, I will draw attention to Weil's idea of a philosophical approach to teaching science in school. She observes that contemporary science – above all, mathematic – is, given its abstract character, being taught in a very dogmatic way. This leads, according to her, to a kind of intellectual subjugation, where students are not given explanations that would help them understand the sense of certain operations and integrate this new knowledge into a broader intellectual context but are rather trained to "playing the game" (e.g., calculating) blindly. In a brief essay entitled *The teaching of mathematics*, Weil comes up with a brief didactical concept that aims, on the one hand, at pupils philosophical understanding of the subject (mathematics as a product of human thought, not merely a set of dogmas). On the other, it should make them aware of the social context where scientific theories arise from, and of the practical context where they are being applied.

1. Simone Weil's approach to and understanding of science

In what follows, I will outline Simone Weil's main points of criticism of contemporary science and her understanding of science and education more generally. I will also comment on the perspective Weil adopts throughout her writings on science, which can be judged neither universal nor clearly historical. Although she raises arguments against and in favour of contemporary positions in general, she sees them at the same time as products of the evolution of certain paradigms of thinking. So, her aim is not only to point out problems with some features of science at her time, but also to connect them to previous developments that have, so to say, let to the *status quo*. Despite some caveats and shortcomings that arise from this double account, one could say with Brendan Larvor that Weil's critique of science strives towards a historically engaged and self-aware philosophy.[1]

I will also say a view words about her terminology (e.g., how she uses "science" or "philosophy") as well as about the historical context of her critique. The aim is to open up a meta-perspective that allows for a better understanding and evaluation of Weil's ideas. Simone Weil was not only a philosopher, but also a political activist (Rozelle-Stone and Davis, 2020). Writing in the nineteen-twenties, she was not only witness to some of the most ground-breaking scientific discoveries of the century and the so-called "second birth" of mathematics, but also faced the social grievances of the industrial revolution and the political impotence of the interwar years.[2]

Let me start with the historical context of Weil's critique. "Historical context" implies here two sorts of things: On the one hand, as above mentioned, there is the historical account of science provided by Weil herself. This kind of context is explicit in her writings in so far as it roots certain contemporary developments of contemporary science in the history of ideas. However, these accounts vary greatly in both accuracy and clarity. While she analyses some aspects in great detail, other issues are being reconstructed only fragmentarily and are therefore difficult to reconcile with today's accounts on the issue. On the other, there is the contemporary historical context of Weil's critique. It puts her views into perspective by showing how her critique relates

[1] Larvor, B., 2008. What Can the Philosophy of Mathematics Learn from the History of Mathematics? Erkenntnis 68, 407.

[2] This second point becomes particularly relevant in her criticism of science's "disconnection from society" (chapter 3).

to certain intellectual traditions and ongoing discussions at her time, as well as Weil's own philosophical background (e.g., authors and traditions that have influenced her thought). The first kind of "historical context" shall be addressed when reconstructing Weil's arguments. Where it sheds further light on Weil's views (especially when her own account leaves questions unanswered), I will provide some historical context of the second type. The aim is to better understand Weil's complaints about certain aspects as well as to get a better picture of Weil's own ideas about science.

With "science" she mainly intends mathematics and physics, and given the academic landscape of her time, they are strongly intertwined with what we call today the "philosophy of mathematics" or "philosophy of physics". Philosophy, in Weil's terminology, just like in the language use of her contemporaries, is typically referred to as such and does not fall under the category "science" or "sciences". This is relevant in so far as the early twentieth century brought along substantial changes of the academic landscape in most European countries: for example, the boundaries between the so-called sciences and the arts became more pronounced and scientific discourse became more specialised and isolated (Ringer, 1992, 124).

Two main points of criticism

The two main points of criticism can be summarized as follows:

[1] The first complaint, to which I will refer by "science's disconnection from reality", has to do with the role of "truth" and its representation in science: Weil sees both sciences – mathematics and physics – constantly moving further away from human life-world experience, grounding their truth value in the consistence of models rather than in what we ordinarily perceive as "nature" or "reality" surrounding us. Contemporary Physics describes, according to Weil, rather models and abstract images of reality than reality itself. Contemporary geometry has moved away from intuition (space as we perceive it) and became a branch of "pure mathematics". Three-dimensional or Euclidean space, which is at the bottom of our perception and image of reality, has turned into a relativist framework with no objective claim to truth.

These developments mirror, in Weil's eyes, a gradual change in our understanding and way of "doing science". Her criticism is not an inner-mathematical or inner-physicist one, accusing particular theories and methods of being inconsistent or false, but consists in pointing out how these developments alter science's role in society and human self-understanding. Furthermore, Weil analyses how they drive into the shadows more general – philosophical – questions about the role of truth in science and its connection with perception and the human mind.

The traditional foundationalist (axiomatic) view that is so deeply rooted throughout the Western tradition from Euclid through Descartes to the present day is not abandoned but considerably weakened[3]: Although sticking to the axiomatic model in general, many contemporary scientists no longer support the realist stance (e.g. Platonism), but adopt a conventionalist or anti-realist attitude towards those "basic truths", taking them not as the, but simply one possible "starter set" on which to build a body of knowledge (Corry, 1997).

Now, the question is what those "axioms" of "basic truths" are and where we get them from. Weil thinks that this is precisely the kind of question scientist should worry and care most about, because "getting it right" requires, in her eyes, starting from the "right" basic assumptions – assumption that can be considered really true: true in our world, true for us humans. Scientists should, above all, seek such truth. Furthermore, they should seek to connect new discoveries not only to the existing scientific body of knowledge, but also to "ordinary thought". Scientific knowledge, although much more specialised, accurate and complex, should be an enrichment and asset (in the sense of an extension) to conventional knowledge and everyday life experience, not a replacement.

Weil's concept of reality is key here and need some further comment: For her, reality certainly includes – in a Kantian sense – some basic principles of physics and mathematics (some analytic *a priori* that are "self-evident", such as space-time perception), but also what allows us human beings to make sense of our experiences. Although showing some Platonic tendencies, she does not go so far to say that we perceive the world objectively, exactly as it is (say, as God created it) nor does she hold that reality is entirely "constructed". She does not defend a particularly refined position in this respect but simply assumes that our view of the world is, to some extent,

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[3] With "weakened" I intend "metaphysically weakened".

affected by our “standpoint”. Standpoint should be understood here in a broad and very basic sense (our intellectual and physical abilities, needs, aspirations, what we might in sum call our “human condition”). Her argumentation relies mainly on the idea that since “human reality” is the only reality we’ve got, and science should deal with reality, science should seek to help us make (more) sense of “human reality”. Rather than seeking a truth “beyond” the latter by “inventing” new, more convenient sets of axioms and reducing the tenants of our perception to “the simplest choice”, scientists should investigate what lies at the bottom of our experiences, feelings and cognitive abilities.

Thus, the idea of “alternative” or “interchangeable” axioms is in Weil’s eyes simply misleading[4] because our perception and cognitive abilities do work in a particular – not in a modal – way. Our feeling and perception cannot be “modelled” differently. They are necessary to the extent that their conditions of existence are “inborn” in our nature. We do live in three-dimensional space and think of two parallel lines of whatever length as never meeting each other. Science as a human activity *for* humans should therefore take these basic truths not just as one possible way to “dress up” reality but consider them as true starting points.

One of the problematic consequences of the unintelligibility of scientific theories is the incommensurability between ordinary thought and scientific thought. Some theories, like the Theory of Relativity or even branches of science, such as non-Euclidean geometry and Quantum physics are so “counter-intuitive” in their structure that that it is impossible to find analogies for them and translate them into ordinary thought/common sense. Knowledge differences between scientists and lay people are then no more differences in degree, but rather is there an “abyss separating the savant” and the ordinary person. When discussing the role science plays in society (see chapter 2, especially 2.4), Weil holds that science in this way helps increasing knowledge-related power structures and the forming of epistocratic elites.

Another consequence from science turning away from the human lifeworld is that it alienates “us” humans from our understanding of reality by means of technical instruments and abstract concepts: If what counts as “reality” is determined by the scientifically measurable or abstractly construed, this also entails a radical selection of what counts as reality worth considering. One

[4] “Misleading” does not refer to logical or empirical falsehood but is a normative claim (something close to “morally wrong”). Science should, according to Weil, aim at different things.

example Weil gives here is concepts which stem originally from the lifeworld and out of ordinary language, and are being imported into science (e.g., like "work" in physics). Initially as an analogy still relying in its meaning on the real-world phenomenon, they become over time an independent abstract concept that, in the long term, seizes and alternates the meaning of our common-sense notions. We then tend to "forget" that work involves other than force (effort) and displacement also things such as hope, dignity, aspiration, and suffering. According to Weil, this leads to an alienation from the lifeworld and indifference towards human needs.[5]

[2] The second complaint, to which I will refer by "science's disconnection from society", is closely related to the former and has to do with certain attitudes towards science and the role it plays in society displayed by scientists at her time: On the one hand, they adopt a pragmatist or instrumentalist attitude towards science: new methods are being justified in light of the technical applicability and predictive successes they bring along. Doing so, science is being reduced to "a mere tool", as Weil claims, and put it into the service of the industry. On the other, scientists proclaim that science should be done "for science's sake", arguing that scientific inquiry has its own dynamic and should not be influenced or constraint by "external" concerns and interests, be they of philosophical, political, or economic nature.

If not a contradiction, Weil sees at least a problematic tension between those two kinds of attitude. More importantly, however, she disagrees with both: What gives science its value, according to her, is the significance it bears for society as a whole and for the lives of the people living in it. On the individual level, science should encourage self-determination, self-expression, and self-knowledge: It should help one make sense of their experiences and being in the world, become a self-determined agent and author of one's own life. With regards to society, it should guide us in our reflections about values and "ideas of the good" and help us design community life in accordance with it. So, it shouldn't be "science for science's sake" but rather "science for the people's sake".

[5] With "we" Weil refers, on the one hand, to the "ordinary person" who is alienated from her self-image and perception, but, even more importantly, also to a larger "political body" and its institutions. Weil herself was not only a philosopher but also a labour right activist in the nineteen-twenties and -thirties. In her later writings, she connects some of her early ideas to her observations of the living conditions of working-class people. I will say more abut this in Chapter 3.

Now, one could argue that technical success, predictability of natural phenomena and economic growth are, at least indirectly, tied to people's well-being. Advances in medical technology and engineering ease the burden of illness, pain and physical labour, they promote economic wealth and make individuals depend less on social cohesion and the goodwill of others. Weil disagrees with this in two points: First, science – as it is now – has a one-sided approach to technological progress and growth, namely a positivistic one that focuses exclusively on the technological and economic side but does not consider the moral and social consequences these discoveries may entail (for example, its effects on warfare or labour conditions in the industrial sector). Furthermore, science's great economic utility brings with it the danger of becoming a commodity on the capitalist market and thereby being corrupted in its research goals.

Second, Weil does not think that the sort of well-being promoted by engineering and economic growth is essential to "lead better lives". This has mainly to do with her anthropological view of human beings. Weil conceives of humans as fundamentally striving towards understanding and making sense of their being in the world. She does not claim that economic well-being or a more comfortable life have any negative effects in themselves on people, or that they are unimportant to uphold. But she thinks that they can in no way compensate for existential grievances, such as being alienated, disorientated, and intellectually subjugated. Scientific progress should not only be applied to the industry but also used to foster social and educational progress.

Analogously to her reflections on industrial labour in the age of more and more complex machines, Weil observes that science – above all, mathematics – is, given its abstract character and ever-increasing complexity, being taught in a very dogmatic way at school. For example, students of mathematics are not given proper explanations that would allow them to really understand what is at stake in the mathematical operations they learn to execute, let alone what has led mathematicians to their discovery. As a consequence, they are not able to integrate this new mathematical knowledge into their broader intellectual landscape (connection to their life-world) but are rather trained to learn "playing the game" by calculating, so to say, blindly. In her remarks on the oppression of the working class, Weil make similar observation about how workers become subdued to the "blind" mechanism of the machines they are executing and consequently become themselves, so to speak, "part of the machine". I will refer to this last by intellectual subjugation.

1.1. Mathematics and physics in Weil's philosophy of science

In view of these points of criticism – science's disconnection from reality, its instrumentalist tendencies, its societal effects of alienating the life world and intellectual subjugation in education – one wonders what "science", that is what mathematics and what physics Weil is here referring to; "what" meaning the understanding of these sciences. At this point, I will address the view Weil holds on mathematics and physics. Being a philosopher with a great interest and good general education but not a professional mathematician or physicist, Weil is mostly concerned with philosophical issues and implications of mathematical and physical theories.

Weil does not offer extensive accounts on specialist issues in Mathematics and Physics, nor does she address a great variety of topics, but limits her analysis in Mathematics, for instance, mainly to Geometry. As already pointed out, Weil's main interest, that is the aim of her critique, lies elsewhere (namely with the consequences developments in science have on a broader scale). At the same time the issue should not remain unaddressed, for it opens an important meta-perspective on Weil's critique – did she, for instance understand the objects of her critique correctly? Is she fair towards the theories she criticises? I will take on such a meta-perspective exemplary when discussing conventionalism in mathematics as sustained by Henri Poincaré. Here, I will not only lay out Weil's and Poincaré's arguments, but also critically discuss her reading.

At this point, my objective is rather to point to the different layers in Weil's philosophy of mathematics and physics that have guided me in reconstructing her arguments.
A first series of questions targets Weil's personal understanding of Mathematics and Physics *as subjects*, that is her understanding of their objects of inquiry and how they relate to nature and our minds. What are mathematical objects and how can we know and talk about them? How do they rely to the natural world and our minds? In what sense is physics the science of "experience" and what roles plays mathematics in it? What are space and time, matter, and extension, and how can we know about them?

Closely related, but not identical to this first aspect is Weil's understanding of Mathematics and Physics *as sciences at her time* – the most outstanding scientists and theories, the institutional and cultural contexts they are embedded in, their achievements, aims and aspirations as well as their history. Here, we find both descriptive and normative elements – the former describing her understanding of "what there is" in Mathematics and Physics at her time and how these disciplines "got there" historically, the latter meaning her opinions on the issues described ("good" and "bad" theories, great and negligeable discoveries, important traditions, and schools, aims and aspirations). These are, in turn, shaped by her own ideas what they should be like (e.g., Weil's ideas on what makes theories, attitudes, achievements, scientist, etc. good and why).
So, the questions are here: Which theories, scientists, contexts and aims does she take into account when talking about contemporary Mathematics and Physics? How (well) does she understand them (compared to other sources) and where does she put the emphasis on? How well, in her opinion, do these two science, Mathematics and Physics, describe and explain the subject matters mathematics and physics, (as she understands them, see above).

A third point, also strongly connected to the second aspect described above, is Weil's idea of science in general, that is mainly what kind of activity science ought to be and what role it should play in society and everyday life. What is, according to Weil, sciences', and thus all individual sciences', *qua science* purpose? And to what extent do contemporary Physics and Mathematics live up to these general expectations? I will refer to this idea by "science in general". As we will see shortly, Weil's idea of "science in general" is strongly bound up with her ideas about education.

The first two layers shall be brought forward when discussing Weil's critique of contemporary science: Here, I will have a look at the authors she cites, as well as the theories and ideas she discusses. The third aspect shall be addressed in the next subchapter. I will further comment on the closely related issue of education in the third chapter.

1.2. Science and education

The differentiation between *science in general* and individual sciences may appear strange to some contemporary readers. However, it is not with regards to Simone Weil and early twentieth century philosophy of science. In fact, there is nowadays not much talk of “science in general” (at least not among scientists), not least in view of the fragmentation and compartmentalization of today’s academic landscape.[6] Additionally, there have been recent reports of revival tendencies of “Bernalistic views of science” in Western societies, arguing that science has no “greater goal” beyond contributing to satisfy the material needs of society and foster economic growth (Rull, 2014; Rull, 2016). More moderately, instrumentalist positions determine the value and relevance of theories in terms of their usefulness in the explanation and prediction of phenomena (John, 2009). So, one may reject “science” as the unity of all sciences in the institutional sense as simply counterfactual; and, one may reject “science” as an idea, arguing there is no goal “beyond” science’s contribution to concrete societal needs.

However, Simone Weil and (some of) her contemporaries embraced, as we will see, both: science as a multifaceted but institutionally united enterprise, and science as an idea, seeking knowledge for a greater good. For one thing, the scientific landscape in the late nineteenth and early twentieth century was not as fragmented as it is today – both Mathematics and Physics used to include what we now call “their philosophy”, that is matters of metaphysics, epistemology, and methodology, and to a relatively great and general extent. For another, Simone Weil is an idealist[7] with strong humanist aspirations for science and education. In her eyes, the aim of seeking knowledge, besides admiring the world’s beauty, is to enable ourselves, as rational human beings, to make sense of our perception and mental processes by means of our capacity to think and act, to further our understanding of nature and our place in it and yield self-determination and human freedom.

> La fin de la science est […] d'abord de rendre l'esprit humain maître, autant que possible, de cette partie de l'imagination que la perception laisse libre, puis de le mettre en possession du monde. (Weil 1966, 65)

According to Weil, to make oneself knowledgeable and to make oneself master of oneself (in the sense of author of one’s own life, a self-determined agent) are not and should not be, as they first seem, two entirely different undertakings. They should rather go hand in hand. Knowledge

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[6] The “fragmentation of academic disciplines” has been listed a world problem, although a “fuzzy exceptional one”, by *The Encyclopedia of World Problems and Human Potential*, published by the Union of International Associations (UIA), accessible here: http://encyclopedia.uia.org/en/problem/134064 (17.10.2022).

[7] I mean Idealism in the sense of an anti-pragmatist attitude, not as opposition to materialism.

and education should not remain purely on the theoretical level but be accompanied by self-reflection, political awareness, and moral maturity.

> Ainsi se rendre savant et se rendre maître de soi, ces deux entreprises qui me semblaient entièrement distinctes, et dont la première me paraissait d'ailleurs de beaucoup la moins importante, je reconnais qu'elles sont identiques. (Weil 1966, 44-45)

This strongly Enlightenment-inspired understanding also includes the advocacy of secularization, opposing knowledge-related power-structures in society and the forming of epistocratic elites. In the introduction of her dissertation, when addressing new developments in Mathematics such as Non-Euclidian Geometry, Weil wonders whether science is still "on track" of its mission to offer people an escape route from their (self-imposed) immaturity: Does science still seek and proclaim truths that we can see with our own eyes and think through with our own minds? Are "ordinary people" capable of grasping the "scientific truth" about the world they live in? Or has modern science degenerated into a stand-alone theoretical structure so complex and inherently different from ordinary thought, language, and perception that common have to rely on as much – and maybe even on more – professional exegesis as for understanding the truth of the bible? And if so, does modern science give thereby rise to a new caste of priests who fulfil that role? Legitimate, because they are able to employ and translate the "right view", because they penetrated the realm of true insight?

> A-t-elle [la science] remplacé les prêtres tyranniques, qui régnaient au moyen des prestiges de la religion, par de vrais prêtres, exerçant une autorité légitime parce qu'ils ont véritablement entrée dans le monde intelligible ? Devons-nous nous soumettre aveuglément à ces savants qui voient pour nous, comme nous nous soumettions aveuglément à des prêtres eux-mêmes aveugles, si le manque de talent ou de loisir nous empêche d'entrer dans leurs rangs ? […] Rien n'est plus difficile, et en même temps rien n'est plus important à savoir pour tout homme. Car il ne s'agit de rien de moins que de savoir si je dois soumettre la conduite de ma vie à l'autorité des savants, ou aux seules lumières de ma propre raison ; ou plutôt, car cette question-là, ce n'est qu'à moi qu'il appartient de la décider, si la science m'apportera la liberté, ou des chaînes légitimes. (Weil, 1966, 11-12)

Weil's understanding and critique of science addresses, besides this political dimension (the role science and scientist play in society), also fundamental theoretical questions. What is it that makes the scientific world-view true, and truer than "ordinary" worldviews?

So, one direction Weil's criticism takes is to what extent contemporary Mathematics and Physics, as she understands them, live up to science's general goals and societal functions I just mentioned. Another direction is to what extent they correspond to what Weil takes as the "nature of their subjects", that is how they relate to the material world and the human mind.

This second aspect is partly addressed in her remark that it is science's goal "first, to make ourselves master of that part of our thinking which perception leaves free, and then, to make us in possession of the world" ("d'abord de rendre l'esprit humain maître, autant que possible, de cette partie de l'imagination que la perception laisse libre, puis de le mettre en possession du monde"). This needs some further explaining. What does Weil mean by "the part that perception leaves free" science should take care of first?

Weil assumes that our thinking is, to a certain degree, determined by what our perception. We are not free to feel or sense the "material world" differently that we use to, there are some "immediate impressions". However, we are free to some extent to reason about and make sense of the latter in different ways. Although some of our concepts are inborn – like time and space – human beings can adopt different perspectives on the "input" of the outer world. How much importance do we give certain phenomena? Which categories do we chose to apply, and which values? How do we position ourselves towards our environment? This is the "part left free" that allows us to become "masters of ourselves". Weil does not assert complete freedom on these affairs – but she assumes that we can actively engage in the process of transforming perception into conscious experience. We should make our choices about those normative issues in first instance, rather than in the aftermath, naturalise them or leave them implicit.

To say this is science first concern means, on the one hand, to adopt a rationalist epistemology rather than an empiricist one. The opposite would mean to start with empirical observation and model our concepts, and our reasoning about it, accordingly. It means that science is and ought to be first of all a "human enterprise", concerned with what matters to us. Nature does not need science. Humans do – in order to make sense of it. Therefore, this should be the starting point.

2. Science's disconnection from reality

I shall start with the first issue, that is science's disconnection from reality. As introduced above, the following of Weil's arguments shall be explained and discussed under this point:

First, sciences such as mathematics nowadays mainly deal with structure and form, rather than with content. There is an increasing hostility and/or disinterest among scientists towards "doing metaphysics". Metaphysics – an assumption on what "there really is" – is the very basis and necessary for any scientific investigation. Sciences' refusal to deal with it[8] deprives science of its content and its connection with the real world.

Second, what we humans perceive and think of as reality is shaped by our – biological, psychological, existential – condition. We do not have "objective access" to the world independent of our standpoint. In this sense, any empirical observation is "theory-laden" (hence the necessity to do metaphysics). Science as a human endeavour should take account of our human reality (meaning existential experiences and the social world). The theories we adopt in science should therefore be in line with our perception, intuition and most important values and concepts, or at least not run counter to them.

As mentioned previously, Simone Weil takes a special interest in Physics and Mathematics as well as their relationship. In her dissertation, she offers an analysis and critique of some theories and developments in the History of Mathematics and of Physics, points to larger socio-cultural and intellectual implications of the latter and advocates for and against certain values and aspirations, epistemologies and methods in science more generally. I will now turn to some of these historical accounts and discuss them in light of the arguments I summarised above.

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[8] With "refusal" to deal with metaphysics she means, on the one hand, positions like logical positivism (associated with the idea that science should be "purified" of metaphysics, such as held and defended by most members of the Vienna Circle). On the other, it refers to antirealism (conventionalist or formalist positions), strongly present in contemporary mathematics. I should add that those positions were at the time much less "philosophically refined" than they are today. Alternatively, one can understand it also more generally, in many young scientists' refusal and disinterest to engage in discourse on the metaphysics of, say, mathematics, declaring it as a "merely philosophical problem" that does not regard them.

2.1. The unity of knowledge and the togetherness problem

In the introduction to her dissertation *Science et perception dans Descartes*, Simone Weil holds that contemporary science investigates only abstract ("pure") structures and seeks to cut its relationship with intuition. More than that, it – that is, the people pursuing it – are allegedly hostile towards intuition and "seek to ban it". Those relationships science tries to examine are, however, 'without content'. And where could "content" be taken from, if not from "experience"? In this sense, it is "speculative" instead of analytic of nature and has become completely inaccessible to non-scientists.

> Les notions du sens commun, tels que l'espace à trois dimensions, les postulats de la géométrie euclidienne, sont laissées de côté ; certaines théories ne craignent même pas de parler d'espace courbe, ou d'assimiler une vitesse mesurable à une vitesse infinie. Les spéculations concernant la nature de la matière se donnent libre cours, essayant d'interpréter tel ou tel résultat de notre physique sans s'inquiéter le moins du monde de ce que peut être pour les hommes du commun cette matière qu'ils sentient sous leurs mains. Bref, tout ce qui est intuition est banni par les savants autant qu'il leur est possible. […] La science s'est purifiée de ce qu'elle avait d'intuitif, nous l'avons remarqué, jusqu'à ne plus concerner que des combinaisons de purs rapports. Mais il faut bien que ces rapports aient un contenu, et où le trouver, sinon dans l'expérience ? (Weil 1966, 10-11)

Although she does not, as we will see, criticise this ambition per se, she deplores the thoughtlessness with which mathematicians transform the discipline, ignore, or even oppose to taking into consideration whether the axioms they adopt can somehow be relied to our intuitive grasp or not. Then she points out more generally that regardless of the degree of formal rigour of our theories, we still need "content", that is a metaphysical foundation of the latter. And where else could the latter be taken from if not "from experience"?

This last bit – the reference to what she calls "experience" is interesting because it suggests at first sight an empiricist epistemology, such as defended, e.g., by Einstein for Geometry (see below). However, this is not what Weil has in mind. As we will see shortly, she does not share the logical positivist idea of the possibility of "objective observation" of natural phenomena. This is mainly so because she thinks that any kind of observation is *a priori* "theory-laden", empirical experiments included. There is "guidance needed" in observation. And rather than choosing "any theory" (that is any metaphysical foundation), Weil argues, we should take into account what makes reality as we experience it. We should adopt a normative framework that is "meaningful" to us.

> Toute pensée est un effort d'interprétation de l'expérience, interprétation pour laquelle l'expérience ne fournit ni modèle, ni règle, ni critérium ; on y trouve les données des problèmes, mais non pas la manière de les résoudre ni même de les formuler. Cet effort a besoin, comme tous les autres, d'être orienté vers quelque chose ; tout effort humain est orienté ; quand l'homme ne va pas quelque part, il reste immobile. Il ne peut se passer de valeurs. À l'égard de toute étude théorique, la valeur a nom vérité. Les hommes faits de chair, sur cette terre, ne peuvent sans doute avoir une représentation de la vérité qui ne soit pas défectueuse ; mais il leur en faut une ; image imparfaite de la vérité non représentable que nous avons vue, comme dit Platon, de l'autre côté du ciel. (Weil 1966 : 143)

This refers, on the one hand, to the "framework" of our perception – Weil calls this intuition. At this point it is important to note that Weil's understanding of the concept of intuition has a strong Kantian underpinning, assuming that the fundamental concepts shaping and structuring our perception such as time and space are inborn in humans. They are what makes up our experiences in the sense that they function as a basic framework of the representation of sensory input in our minds. On the other, there are "values" – shared normative assumptions that shape our ideas and experiences of "things" as "justice", "dignity", "human", "effort", "good life", "suffering", "true" etc. Depending on our values, we experience events differently.

Let me sum up Weil's argument so far. Weil holds that contemporary science investigates only abstract ("pure") structures and seeks to cut its relations with intuition. She sees two kinds of problems here that tie in with the two arguments on metaphysics as I reconstructed them at the beginning of the chapter. The first is, that in her view, "form needs content". This is true for both mathematics and the empirical sciences. For example, contemporary Geometry builds on axiomatic systems that are not concerned anymore with physical space or "the material world surrounding us", as was once Euclidian Geometry. The new geometers freely adopt a metaphysics that satisfies best their respective needs.[9] This "freely chosen" or "speculative" metaphysics is, however, completely foreign to human reality (how we grasp and explain the world through perception and reasoning), so Weil.

This has, on the one hand, to do with Weil's understanding of human perception and, on the other, with some of her ideas about the kind of knowledge science should produce. I shall start with the latter, which I will call "the unity of knowledge" idea. This connects to Weil's remark

[9] I will say more about the choice of axioms and axioms picking out their models in the following chapters, and especially in 2.5.

about the “human reality”, which consists not only of natural phenomena but also of social categories and what she called “values”.

Now, it is a bit of a stretch for the contemporary mind to imagine mathematics and empirical sciences such as physics dealing with moral or political issues. However, the idea of a “unity of knowledge” that is often associated with Greek Antiquity and Christian ideology regained great popularity throughout the seventeenth- and eighteenth-century Enlightenment movement and had a long-lasting effect on rationalist images of knowledge, especially in the French tradition (Cat, 2022). Although construed differently among individual thinkers, there is a shared “cosmological” belief: The universe, as a whole, is harmonic and one, governed by eternal laws and forms. Science is one way of representing the world. If one believes in the existence of such a cosmic order and that we have access to it, it seems almost natural that science, as a representation of such a universe, ought to mirror this order or structure in some way.

However, opinions differ in which way science should do this. There are certainly different branches and fields of science with different subjects of study. One traditional view, supported, e.g., by Aristotle, is that these subjects are all “united in nature” (meaning they interconnected and parts of a whole system in the natural world) and that it is therefore metaphysics “that comes to provide knowledge of the underlying kind” (Aristotle in *On The Heavens*, cited after Cat 2022). Two thinkers who developed this idea further into a rationalistic direction, and who strongly influenced Weil’s philosophy, were Descartes and Leibniz.

> Descartes and Leibniz gave this tradition a rationalist twist that was centered on the powers of human reason and the ideal of system of knowledge, on a foundation of rational principles. It became the project of a universal framework of exact categories and ideas, a *mathesis universalis* (Garber 1992 and Gaukroger 2002). Adapting the scholastic image of knowledge, Descartes proposed an image of a tree in which metaphysics is depicted by the roots, physics by the trunk, and the branches depict mechanics, medicine and morals. Leibniz proposed a *general science* in the form of a *demonstrative encyclopedia*. This would be based on a “catalogue of simple thoughts” and an algebraic language of symbols, *characteristica universalis*, which would render all knowledge demonstrative and allow disputes to be resolved by precise calculation. Both defended the program of founding much of physics on metaphysics and ideas from life science (Smith 2011) (Leibniz’s unifying ambitions with symbolic language and physics extended beyond science, to settle religious and political fractures in Europe). By contrast, while sharing a model of geometric axiomatic structure of knowledge, Newton’s project of natural philosophy was meant to be autonomous from a system of philosophy and, in the new context, still endorsed for its model of organization and its empirical reasoning values of formal synthesis and ontological simplicity (Cat 2022).

This comparison between the rationalist and the Newtonian project nicely displays how Weil's idea can be positioned in this respect. As we will see, her ideas about science have a strong resemblance with those ascribed here to Descartes and Leibniz, and her criticism partly opposes an "autonomous" axiomatic understanding as presented by Newton. Weil might not go so far as Leibniz' late attempts, but she definitely adheres to the idea of science as an integral part of the "general" system of philosophical knowledge and a metaphysics that somehow unites – or at least connects – those different parts.

Second, the idea of science as a representation of the structure of the universe is not all there is to her criticism. She definitely ascribed to the traditional view that science should portray the unity of knowledge with mathematics at its core, but she is also concerned with the practical significance of science and its outcomes with regards to life in society. Throughout her critique of science, Weil holds that scientific knowledge should be applied to "moral concerns" and "life-world experience", that is to human rights and social progress. She repeatedly points out that science and its "products" (e.g., developments in the industry") have an impact on life and society – be it intentional or unintentional. She highlights, for example, that in "real life", other than in the realm of science, we are not as indifferent, and open-minded towards potential outcomes. She does not go so far as saying that science should actively aim at "promoting the good" in a particular way, but it should at least take on some responsibility for how it affects life in society. Nature does not need science. Humans do – in order to make sense of it. According to her, the new sciences, however, seeks to surpass those boundaries, and deal with a reality more fundamental, more general, and "truer" than the one we "touch with our hands" or see with our own eyes (Weil 1966, 12).

In what follows I will analyse Weil's reflection on the issue more closely by looking at her historical account of Geometry and the role her understanding of human perception plays in this context. I will contextualise her remarks with other literature where needed in order to better understand what exactly she is referring to and contrast her position with opposing views.

In Weil's writings, Geometry is not mainly addressed as a sub-discipline of the mathematical body as a whole, but rather as a 'mathematical science' on its own, not unlike physics. The sort of traditional or "classical" view of geometry – and this is what Weil has in mind when referring to three-dimensional space and Euclidian postulates – is that it is fundamentally about describing matter and extension. Although its truths seem necessary, geometry also deals with the relations between the properties of physical bodies – it describes relations between magnitudes such as lengths, angles, areas and volume in space. As the historian of science Ernest Nagel points out in his well-known essay "The Formation of Modern Conceptions of Formal Logic in the Development of Geometry" (1939):

> Although geometry originated in the arts of land mensuration, […] it could not be denied that the method of geometry was not empirical, and the acceptance of the truth of geometrical theorems did not wait upon observation and experiment. That the truths of geometry are "necessary" in some sense which is not merely factual or experiential, and that geometry does formulate relations between properties of bodies, were two conclusions which seemed inescapable and at the same time difficult to reconcile. The various philosophies of classical rationalism, classical empiricism, and Kantianism, were […] heroic attempts to establish some sort of uneasy balance between them. What is common to them all is the view that the geometry systematized by Euclid is the definitive science of space or extension (Nagel, 1939, 143).

This "uneasy balance" or epistemological problem of reconcilement of forms and content that Kant and others "heroically tried to solve" is now sometimes referred to by the name "togetherness-problem" (see Hanna 2022). It is one of the most discussed issues in the History of Philosophy and raised by both Nagel and Weil in their remarks cited above. The tone of Weil's exclamation that "forms obviously need content and where should it be taken from if not from experience" (« Mais il faut bien que ces rapports aient un contenu, et où le trouver, sinon dans l'expérience? », see quote above) evokes effectively strong associations with Kant's formulation of the problem:

> Intuition and concepts … constitute the elements of all our cognition, so that neither concepts without intuition corresponding to them in some way nor intuition without concepts can yield a cognition. Thoughts without [intensional] content (Inhalt) are empty (leer), intuitions without concepts are blind (blind). It is, therefore, just as necessary to make the mind's concepts sensible—that is, to add an object to them in intuition—as to make our intuitions understandable—that is, to bring them under concepts. These two powers, or capacities, cannot exchange their functions. The understanding can intuit nothing, the senses can think nothing. Only from their unification can cognition arise. (A50–51/B74–76, cited after Hanna 2022)

Naturally, the problem does apply not only to mathematics but to cognition and its objects in general. However, mathematics, and especially geometry, constitute – for the reasons given by Nagel – a sort of prime example of the problem. Kant's account of Geometry as synthetic *a priori* had strongly influenced Weil (and French scientists in general). As we will see, Geometry's departure from intuition in the nineteenth century did not solve but, in a certain sense, worsened the togetherness-problem as described by Kant.

Even though Kant's account, being certainly one of the most impressing attempts to solve the epistemological puzzle, was not uncontroversial, philosophers like Weil felt it offered at least the *kind* of answer they could accept. Comments on Kant's philosophy of Mathematics at the time typically aim at developing further or opposing his ideas. The disagreements target parts of his theory – but not the attempt in general (Greenberg 1993, 200f.). Although there were disagreements in many points, philosophers seemed to think that by attempting to reconcile geometry's empirical and at the same time necessary character, Kant was tackling the problem of *a priori* knowledge from the right angle. This was basically so because there was a common understanding of the problem (and the task it entailed): To come up with an explanation how our limited human minds, trapped in our earthly body's, come to have knowledge that is pure and certain, perfect like empirically gained knowledge could never be, and at the same time, so admiringly appropriate to the objects of reality? How can Mathematics be true in our world, and at the same time in the untimely realm of logic? Even Kant's most ferocious opponents recognised the importance of the question – it had occupied philosophers and mathematicians for millennia. Coffa notes:

> For better and worse, almost every philosophical development of significance since 1800 has been a response to Kant. This is especially true on the subject of a priori knowledge. The central problem of the Critique had been the a priori, and Kant had dealt with it from the complementary perspectives of judgment and experience. His "Copernican revolution" gave him a theory of experience and a non-Platonist account of the a priori. But when the Critique was well on its way, Kant discovered the notion of a synthetic a priori judgment, and he saw in this a particularly appealing way of formulating his project as that of explaining how such judgments are possible. (Coffa, 1991, 7).

The methodological developments in geometry which "freed" it from intuition then gave the question, at least with regards to mathematics, an unexpected twist. When mathematicians came up with other and more general geometries that were not bound up with any sort of experience, they, in a certain sense, took the wind out of the question's sails. These new geometries, logically coherent and from a mathematical point of view as "true" as Euclidean Geometry[10,] suggested that the subject does not necessarily have to do with intuition or proportions in the world as we perceive it – so why keep pressing on their connection? Why not instead opt for a purely abstract, analytically true geometry gaining its truth from consistence and logical rigour alone and abandon the project of reconciling it with human cognition and experience? And,

[10] I will come back to what is meant here by "truth" when I discuss conventionalism.

even more importantly, why keep geometry associated with proportions in the physical world that put a curb on its theoretical development as a branch of pure mathematics?

If not entirely dismissed, this part of the epistemology of mathematics which had occupied intellectuals for millennia was pushed into the background in the end-nineteenth and early twentieth century. This was, on the one hand, due to the most recent developments in Geometry (for details see also the chapters 2.2, 2.3 and 2.4). On the other, it was accompanied and fuelled by new developments in philosophy, such as the emergence of logical positivism and the semantic tradition that "may be viewed as a development to the point of exhaustion of this aspect of Kant's original idea." [11] (Coffa, 1991, 8)

The puzzle of a mathematical knowledge was still admitted an open problem. However, an increasing number of scientists felt that it was a problem not "mathematical in nature". Soon it was largely considered "a purely philosophical problem": in short, a problem mathematics was no longer interested in. In his famous essay "Geometry and Experience", Albert Einstein holds, for example:

> Every one knows what a straight line is, and what a point is. Whether this knowledge springs from an ability of the human mind or from experience, from some collaboration of the two or from some other source, is not for the mathematician to decide. He leaves the question to the philosopher. […] (Einstein and Pyenson 2006, 233)

The validity of "the axioms employed", Einstein tells us, is to be understood in a "purely formal" sense. Modern geometry's entities, denoted by words such as "straight line", or "point" do not refer to any "real objects" but "exist" only in a nominalist sense, being "void of all content of intuition or experience". They are simply placeholders[12] within a structure that is abstract in nature:

> These axioms are free creations of the human mind. All other propositions of geometry are logical inferences from the axioms (which are to be taken in the nominalistic sense only). The matter of which geometry treats is first defined by the axioms. Schlick in his book on epistemology has therefore characterised axioms very aptly as "implicit definitions." This view of axioms, […] thus dispels the mystic obscurity which formerly surrounded the principles of mathematics [but] makes it also evident that mathematics as such cannot predicate anything about perceptual objects or real objects. In axiomatic geometry the words "point," "straight line,"

[11] For a detailed account on the history of these ideas, see Coffa 1991. In what follows, I will turn issues closely related to early logical positivism (as defended, e g., by Schlick, and taken up by Einstein). In chapter 2.4, when discussing Poincaré's conventionalist understanding of mathematical truth, I will make a few remarks that connect to a semantic understanding.

[12] As Hilbert put so pointedly, instead of "points", "straight lines", and "planes", we must always be able to say "tables", "chairs", and "beer mugs" (cited after Reid, 1996).

etc., stand only for empty conceptual schemata. That which gives them substance is not relevant to mathematics. (Einstein and Pyenson 2006, 234)

Indeed, it did not take long until "new mathematicians"[13] suggested than the general and pure science of Geometry, comprising infinitely many particular geometries, was distinct and separate from particular geometrical practise and real-world perception that once constituted the basis of Euclidian Geometry. The latter being still highly relevant to the natural sciences and applied purposes (e.g., architecture, astronomy, mapping) should be kept as a "measuring practise" of "practically-rigid bodies", whose affirmations rest essentially on induction from experience, and not only on logical inferences.

> Geometry thus completed is evidently a natural science; we may in fact regard it as the most ancient branch of physics. Its affirmations rest essentially on induction from experience, but not on logical inferences only. We will call this completed geometry "practical geometry," and shall distinguish it in what follows from "purely axiomatic geometry." The question whether the practical geometry of the universe is Euclidean or not has a clear meaning, and its answer can only be furnished by experience. All linear measurement in physics is practical geometry in this sense, so too is geodetic and astronomical linear measurement, if we call to our help the law of experience that light is propagated in a straight line, and indeed in a straight line in the sense of practical geometry. (Einstein and Pyenson, 2006, 235)

To sum up Weil's argument with regards to the historical context so far discussed: In the nineteenth and early twentieth century there have been (a) a shift in the understanding of "truth" in mathematics and (b) an estrangement of mathematics and philosophy in terms of interests and methods. Those two factors can be regarded as the main driving sources of mathematicians' turning their back on questions of metaphysics and epistemology in Mathematics.

Certainly, mathematics and, more particularly, geometry relying on axiomata and logical rigour was not a new development – those features were already present in Euclid and his followers. However, whereas "traditional" mathematics sought *both* analytic and synthetic truth, the latter dropped with "the second birth" of mathematics (Stein, 1988) out of the picture. For many "new

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[13] I borrowed this expression from Gutting (2001). There is no clear definition of who the "new mathematicians" are, although it is not difficult to assign names to the term. In other literature, one meets also "creative mathematicians", "working mathematicians" and the like, which seem to designate roughly the same. There was no collective that united under such a name. It is rather used in the way we speak of "analytic philosophers", that is to describe mathematicians who do a certain kind or adhere to a certain tradition of mathematics. "New mathematics" or "new maths" refers to fundamental developments that took place in mathematics around 1900 associated with the set-theoretic-axiomatic formulation of the subject. So, in the most basic sense, it means "mathematics developed around and after 1900". These developments and some of their philosophical background shall be discussed in this thesis (mostly in chapter 2). However, "new mathematicians" designates also a certain, that is a progressive, attitude towards and active engagement in these new developments. This term is also relevant in so far as Simone Weil's critique of contemporary science addresses mostly such "new mathematicians" and the "new mathematics".

mathematicians", it was good enough that mathematical statements were true in Mathematics.[14] It was for others – e.g., for the empirical sciences – to decide whether and to what extent they were true in our world.[15]

This went alongside with the growing apart of mathematics and philosophy as academic disciplines, but also increasing differences in terms of their subjects of interest. The matter of synthetic truth of mathematics (questions concerning the "real-world-connection" of Mathematics, in terms of metaphysics but also epistemology) were, of course, still of interest to philosophers, but mathematicians saw them no longer as mathematical concerns. As Einstein hinted in his remarks on the issue, the question of the synthetic truth of certain parts of mathematics were also – besides being non-mathematical – more and more considered an empirical question ("the question whether the practical geometry of the universe is Euclidean or not has a clear meaning, and its answer can only be furnished by experience"). [16]

According to this attitude, Geometry as a subject is sufficiently dealt with by mathematics, on the one hand, and by the natural sciences, like physics, on the other. The former investigates its analytic truth and the latter checks for its applicability. This leaves to philosophers a relatively small niche: To check for logical consistency and to deal with "the mystic obscurity" (according to Schlick), that is a truth "beyond" the universe. In short, the metaphysics mathematicians and natural scientist were no longer interested in. At the same time, mathematics as a body of knowledge became highly specialised and complex in an incredibly short time so that non-experts, among which philosophers, had increasing difficulties to see through its extensive theoretical body. As a consequence, the new mathematics, besides being partially "non-intuitive" became also surprisingly unphilosophical.

[14] The statement that "mathematical statements were true in Mathematics" as presented by Albert Einstein can be regarded as a minimum stance of "formalism" on the matter. It does not implicate a particular position on what mathematics is about, although it rules out Ontological Realism. Indeed, antirealist understandings, among which formalism may been seen as an extremer version, became very popular in the late nineteenth century. While mathematicians were more explicit about this matter in the course of the twentieth century, the first observable trend than accompanied the new Mathematics was rather a – not always well justified – disinterest in metaphysical question (such as e.g. by Schlick and the Vienna circle who defended a positivist stance).

[15] In chapter 2.4 I will further comment on how the rise of non-Euclidean Geometry shaped the "scientific world-view" at the time.

[16] Kant, in contrast, declares that "the concept of [Euclidean] space is by no means of empirical origin, but is an inevitable necessity of thought."

Before moving on to further discussing the developments in the history of Geometry Weil addresses (and therefore allow us to reconstruct and evaluate her criticism), it is important to note that, talking about geometry's subject and truth status on the one hand, and about its historical evolution in terms of methods on the other, there two different – even though interdependent – issues at stake. Those issues can be situated on two planes, or lines of development one can find in the history of the subject: One is the concern what geometry does, as a scientific practise, that is how it is methodologically pursued at different times to certain ends. It investigates what mathematicians do and the results they achieve (let's call this the mathematical-methodological plane). Problems occurring on this plane are "practical problem", like solving an equation, discovering different ways of finding proof etc.

On the second plane, which we might call the philosophical (metaphysical-epistemological), we are confronted with questions like what geometry is (about), what kind of truth it reveals, how its results connect to our mind, world and to other sciences. Problems in this area are "theoretical" or philosophical problems, like the togetherness problem mentioned above. As we have seen, they do not actively "keep" mathematicians from (discovering new ways of) doing mathematics.

As we have seen, Simone Weil was under the impression that contemporary science suffered from a certain asynchronicity or "rupture" between those two aspects, that is, first, mathematicians disregard, carelessness and unreflectiveness with regards to the "philosophical" dimension of the methods they employ, and second, their lack of interest for metaphysical questions and "truth" when it comes to the axioms of mathematics.

On the abstract level, one could say that those two concerns are two sides of the same coin, they go together: if there is a change in how a science is pursued, it necessarily affects our understanding of what it is and what it can tell us about the world. Their strong logical connection requires an explanation of the philosophical consequences that result from changes on the methodological level (and vice-versa). Simone Weil advocates that they also should go together – to not lose science's intelligibility.

In nowadays practice, we see indeed a strong interplay between those two concerns, but historically, in most cases, developments on the two planes do not occur simultaneously. Most scholars agree that since the nineteenth century, the philosophical side of the medal is limping behind. Mathematicians practicing geometry invent new methods to cope with – methodological and practical – problems that consequently challenge prevailing philosophical theories, and philosophers try to come up with new theories, explanations, and theoretical problems in light of the methodological changes in the field.[17] Whereas advancements in mathematics in early Modern times were accompanied and deeply interwoven with philosophical reflections on the issue, the evolution of mathematics from the nineteenth century onwards went off so fast and was so specialized that its philosophical foundations remained in many aspects fragmentary and sketchy. Especially the rise of non-Euclidean geometry in the German tradition (from Gauss to Hilbert) brought along a culture that Zheng (1965) pointedly labelled a "philosophy of mathematics for mathematicians" (cited after Gillies, 1999).

2.2. Analytic Geometry vs. "convenient" Geometry

At this point, I will have a closer look on Weil's statement that the ground for choosing certain axioms should be bound, or at least not run counter, to what she calls "ordinary perception" and "human reality". She makes this point by examining some evolutionary steps from synthetic to analytic Geometry in the era of Descartes and how these developments rely to geometry's metaphysical foundations. Weil's main point is that the analytic tradition starting with Descartes "freed geometry from its cradle" by making it more abstract and more intelligible. However, unlike "new geometries" emerging in the nineteenth and twentieth century, Cartesian geometry combined the analytic method with Euclidean axioms (compatible with perception and ordinary thought). According to her, this is a prime example for actual scientific progress: Investigating "real content" more rigorously by rationally improving our methods (instead of remodelling the content). At this point, I shall also defend Weil against some over-simplified and, as I will show, unjustified criticism in the literature of being a traditionalist with general hostilities towards the analytic tradition and technology.

Now, what happened to Geometry when it became analytic and how did this development affect its "connection to reality" as Weil understands it? As pointed out by Nagel, there is a strong consensus among mathematicians and philosophers that Euclidian geometry "is the science of

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[17] There is an interesting conceptualization of this made by Shapiro that he calls the "philosophy-first" versus the "philosophy-last-if-at-all" attitude also present today (see Shapiro 1997: 143-176).

space and extension" (Nagel 1939). However, the same cannot be said about the geometries to follow. While geometry was traditionally conceived as describing the continuous (that is, the measurable), and therefore taken as a qualitative science, Arithmetic and Algebra, being sciences of quantity, were taken to describe the discrete. There are instances of a rapprochement between those fields in Antiquity, but it was not until the development of analytic geometry that the gap between those subjects has properly been bridged, and their distinction loosened in a sustained manner. Nagel notes:

> Even in antiquity many properties of figures were studied which involved only relations of mutual position and order of figures, and did not in principle depend on relations of equality and inequality of magnitudes. The beginnings of what is now known as projective geometry, which does not employ these relations of congruence, thus go back at least to the time of Euclid, some of whose lost books apparently contained projective theorems. […] However, the systematic investigation of geometric relations which were not quantitative but which lend themselves to as precise a study as the familiar metrical ones, remained uncultivated until the needs of the arts and technology brought them to the attention of professional mathematicians of a much later era. (Nagel, 1939)

Although Weil identified some of those early attempts as roots of what was to be realized centuries later, she seems to share Nagel's viewpoint that it is Descartes and those to follow him who constituted the starting point of what Geometry has eventually become in the nineteenth century. It is not hard to see why this is so: Synthetic Euclidean Geometry (as opposed to Analytic Euclidean Geometry as introduced by Descartes) was, so Weil, literally "glued to the earth" by its methods and instruments of proof: compass and straight edge. In this sense, a synthetic geometrical proof was a demonstration and at the same time a proof of something concrete: The drawn figure.

In her analysis of the Descartes' work, Weil dedicates – full of admiration and acknowledgement – an entire section to discussing Descartes contribution to "freeing science of its cradle" (« la science purifiée de la boue natale »). What did she mean by that?

> c'est dans la révolution que fut, pour les mathématiques, la Géométrie de 1637 qu'éclate surtout cette idée de la pure étendue, de l'étendue en soi, pour parler un langage platonicien. Les géomètres anciens raisonnaient, il est vrai, non pas sur le triangle ou le cercle qu'ils avaient devant les yeux, mais sur le triangle ou le cercle en général ; ils restaient pourtant comme collés au triangle ou au cercle. Comme leurs démonstrations s'appuyaient sur l'intuition, elles gardaient toujours quelque chose de propre à l'espèce de figure qu'elles avaient pour objet. Quand Archimède eut mesuré l'espace enfermé par un segment de parabole, cette admirable découverte ne fut pourtant d'aucun secours pour les recherches analogues concernant, par exemple, l'ellipse ; car c'étaient les propriétés particulières de la parabole qui, au moyen d'une construction impraticable ou inutile pour toute autre figure, rendaient cette mesure possible. Descartes a

> compris le premier que l'unique objet de la science, ce sont des quantités à mesurer, ou plutôt les rapports qui déterminent cette mesure (Weil 1966, 17).

Here, Weil basically asserts that by "discovering"[18] analytic geometry, Descartes accomplished a step of abstraction that rendered the disciplines truly one of relations ("rapport"), rather than concrete objects. True, classic geometrical figures served as concrete model for more general figures, but the discipline remained somewhat "glued to its objects" in the sense that statements about quantities and their relationships were not transferable among different figures (e.g., from parabolas to ellipses).

Now, it is tempting to read her criticism of contemporary science as outlined above as a sort of opposition between the good old "classical science", that is Euclid and his followers, on the one hand, and abstract ivory-tower "modern science", namely analytic geometry starting with Descartes and culminating in non-Euclidean geometries, on the other. Such interpretations have indeed been made by scholars in the past (e.g., Chevanier)[19], not least because of a lack of clarity in Weil's scattered and sometimes indistinct remarks on the subject. Furthermore, Simone Weil's philosophy has so far been mostly discussed within the so-called "continental tradition" in philosophy. Another factor that might contribute to such a reading are some – general, and more radical – remarks on Algebra in her later writings. In light of such interpretations, Weil might appear as a religious traditionalist with hostile tendencies towards science and technology who would have us rather sit around the campfire than model exchanges of energy, work and heat based on the laws of thermodynamics.

Such a reading is, however, a severe shortcoming and does not do, as I will argue, justice to her text and her critique of contemporary science as present in her early works on science.[20] The

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[18] I use here "discover" rather than "invent" to underline Weil's differentiation between "analytic" and "speculative". Whether Descartes was actually "the first" to come up with this is debatable (see: give some literature), but it is true that is was in Descartes' era that this development took place.

[19] "He [Descartes] saw that the signs was essential for thought, but he did not prevent signs from replacing the signified and become their own end (as in the case of Algebra). In short, Descartes failed to discover the way to understand without at the same time ceasing to perceive" (Chevanier: 66); "The Descartes she [Weil] reinvestigated with the aim of discovering an alternative foundation for the modern world is still almost exclusively read and regarded as the foundation of everything that is most oppressive and limiting in modern science and culture."

[20] There is a considerable difference, both in form and content, between her early writings on science and her later writings. As with many other philosophers, there is a "young Simone Weil" and a later one, accompanied by a personal development as well as a change of interests and in some cases opinion. It is not my aim to defend that there is such a distinction or to make claims about the differences. The point here is, that I am interested in some of Weil's early writings on science and do not intent to give overall account on Weilian philosophy.

main problem with this is not so much to misunderstand Simone Weil as a philosopher in general, but to miss out some interesting aspects of her approach to science. In her dissertation, Weil does not express a general hostility towards modern science, nor does she "blame" or criticize Descartes for having initiated or fostered a development that eventually gave rise to the analytic tradition and certain aspects of nineteenth-century science she sees as problematic. She discusses Descartes precisely to point out the opposite.

First, her criticism does not target, as I will show, analytic Geometry in general, but Non-Euclidean Geometries and certain philosophical positions that came along with it. Second, Weil does not claim that they are incoherent or "false" but points out that they have problematic implications for science and society more generally. At the most, one may take her thinking of them as "wrong" in a moral sense.

Her main point of criticism is, as sustained by many of her contemporaries,[21] their complete detachment from intuition and the broader consequences that follow from this feature. Weil did not think, as rightly pointed out by Vetö et al. (1994, 136), that it was Descartes' ambition to "quantify" the world, but to describe the real in the most general intelligible terms which are, in his view, of mathematical character. Descartes had this "genius intuition" that relations are not "part" of the objects but more general structures that "give them their form":

> dans la géométrie, [les rapport] se trouvent seulement comme enveloppés dans les figures, de même qu'ils peuvent l'être, par exemple, dans les mouvements. C'est après cette intuition de génie qu'à partir de Descartes les géomètres cessèrent de se condamner, comme avaient fait les géomètres grecs, à ne faire correspondre une expression ayant un degré quelconque qu'à une étendue ayant un nombre de dimensions correspondant, lignes pour les quantités simples, surfaces pour les produits de deux facteurs, volumes pour les produits de trois (Weil 1966, 17-18).

Third, in her dissertation, Weil chooses a historical approach on philosophy of science because she believes that in order to fully understand social – man-made – phenomena (and scientific theories fall for her under that category), it is essential to consider them in light of their historical evolution. This becomes also clear from her writings on didactics and teaching, where she emphasizes the need to explain to students how certain ideas developed instead of presenting them as ahistorical truths (I will come back to this later in Chapter 3). So, in order to properly understand Weil's criticism about science's disconnection from reality, it is essential to take a

[21] I will say more about such criticism in general in chapter 2.3. For further information on discussions of the role of intuition in Geometry at the time, see Franchella, 2022.

closer look on her reading of Descartes' contribution and how it differs, in her view, from what geometry became in the nineteenth century. Now let us take a closer look this "discovery" of Descartes'.

In the appendix of his famous *Discours de la methode* (first published in 1637), Descartes presents a new account on geometry ("La géométrie") that relates algebraic concepts with geometric objects. In a coordinate system with two fixed lines, each specific point of the plane is defined by a pair of numbers (x, y) that mark its position relative to the coordinate axes. Descartes had devised a kind of dictionary between algebra and geometry, which in addition to associating pairs of numbers to points, allowed him to describe lines drawn on the plane by equations with two variables (x and y), and vice versa. The novelty of this analytic approach to geometry was that it allowed geometric problems to be solved through the exclusive manipulation of algebraic expressions, instead of "drawing the thing out". The nineteenth century mathematician Felix Klein notes:

> Synthetic geometry is that which studies figures as such, without recourse to formulae, whereas analytic geometry consistently makes use of such formulae as can be written down after the adoption of an appropriate system of coordinates. (Klein, 1939, 55)

One side-effect of the evolution of analytic geometry was that synthetic geometry with its reliance on diagrams fell into neglect, even though there always were technicians, but also scientists who still preferred the synthetic method. In the introduction to "La géométrie", Descartes boasted that with his new method, "any problem in geometry can easily be reduced to such terms that a knowledge of the length of certain straight lines is sufficient for construction" (Descartes et al. 1925, 296). [22]

In a certain sense, this 'alternative' or "purer" way of reasoning about geometrical objects may be seen as an important first step in the process of Geometry moving away from intuition. For one thing, the analytic method redirected mathematicians' attention to formal aspects and somewhat away from the question of "truth" of certain axioms and questions related to applicability (the "truth" of the Euclidean axioms was, despite its lack of proof, taken for granted). For another, the moving away from diagrams and visualisation constituted a big step

[22] Similarly, Lagrange, about a century later, proudly announced that his celebrated treatise on mechanics did not contain a single diagram.

in abstraction – it allowed one to solve geometrical problems without thinking about what they would "look like" in the real world (although one could still do so).

Nevertheless, it was mainly a change in methods and style, and not so much in "content", as Weil points out. Note that Descartes still speaks of "the length of straight lines" (quote see above) – his analytic method presented an alternative way of describing what had former been described by means of synthetic geometry, it was just a different way of putting it. True, he invented another, "purer" – in the sense of more general and more efficient – way of dealing with geometrical problems, but those "problems" were not essentially different from the ones tackled by synthetic geometers; they were still located in Euclidean space (thus, built on the same 'basic truths' as the latter). Gray and Ferreirós note:

> Before the 19th century only one geometry was studied in any depth or thought to be an accurate or correct description of physical space, and that was Euclidean geometry. The 19th century itself saw a profusion of new geometries, of which the most important were projective geometry and non-Euclidean or hyperbolic geometry. Projective geometry can be thought of as a deepening of the non-metrical and formal sides of Euclidean geometry; non-Euclidean geometry as a challenge to its metrical aspects and implications. (Gray and Ferreirós, 2021)

Weil emphasis this point when contrasting analytic geometry as discovered by Descartes with the view defended by her contemporary Poincaré. She makes it clear that she is not opposed to the analytic tradition (actually quite the contrary: "it means directing thought properly").

> […] si Descartes, comme Poincaré, demande plutôt à la science de se conformer à l'esprit qu'aux choses, il ne s'agit nullement pour lui de penser commodément, mais bien, c'est-à-dire en dirigeant la pensée comme il faut. (Weil, 1966, 22-23)

The success of analytic geometry, however, left a certain void on the practical plane (Nagel 1939), e.g. 'professional' problems, such as those related to plane representation of three-dimensional figures. These would later fuel the development of projective geometry.

At the same time, analytic Geometry facilitated some tasks considerably in the sense that proportions could be calculated much more efficiently. Mathematicians at Descartes' time, however, did not concern themselves with application problems. Whether his New Geometry was of practical use or not, so Weil, was rather irrelevant with regards to its scientific value. Weil does not seem to take this as a deficiency of the early analytic tradition, but rather as a quality feature. It is indeed "worthwhile to advance this new mathematics", so Weil, not because it provides "idle geometers and calculators" with handy shortcuts for solving their practical problems ("bagatelles", to Descartes), but because it is like "the envelope of real science", the only kind of science that is worth pursuing.

> Aussi cette mathématique nouvelle vaut-elle la peine d'être cultivée, non parce qu'elle nous procure, au sujet de nombres ou de figures imaginaires, ces connaissances que Descartes traite de bagatelles, et qui ne sont, dit-il, que l'amusement de calculateurs ou de géomètres oisifs, mais parce qu'elle est comme l'enveloppe de la vraie science, seule digne d'être cultivée. (Weil, 1966, 25-26)

It may seem strange to discard those positive side-effects of analytic geometry as irrelevant at this point (why not highlight them as a benefit?), but as we will see in chapter 2.4, the issue of "descriptive suitability" will become central to her criticism of non-Euclidean Geometry and its relationship with "truth". So at this point, Weil is trying to point to one essential difference between the analytic tradition in Geometry in general and Non-Euclidean geometries that we should keep in mind. Cartesian Geometry, which she recognises as the "starting point" of a tradition that would eventually culminate in non-Euclidian approaches, gained its value and significance from the fact that is rigorously described what "there really is". Its truth was at the same time analytic and synthetic. Indeed, it was also to some extent useful in practical matters. But what makes it "right", she continues, is not that it is "(more) comfortable" (or practically useful) – as suggested Poincaré – but that it directs thought properly, meaning "in line with how our minds work" (see quote above).

At this point, we learn another important feature of Weil's understanding of science in general. Descartes, like Poincaré, so Weil, requires of science to "conform to the mind rather than to appearances" (« Descartes, comme Poincaré, demande plutôt à la science de se conformer à l'esprit qu'aux choses »), but he does so for different reasons. To conform sciences' "cloak" or form to the structure of our minds, rather than to "things" expresses a rationalist understanding of science[23] as I shortly outlined it above when discussing the idea of "unity of knowledge".

For mathematical knowledge, being the prime model of most rationalist accounts, this means that there must be some innate (inborn or acquired) mental concepts that enable us to explore the depths of numerical relations, construct proofs, and deduce ever more complex mathematical concepts. There is some natural "harmony" or familiarity between our way of seeing and perceiving, the order of the world and mathematical structures. In discovering this

[23] In the literature, this is referred to by the label "Continental rationalism", basically committing to the view that knowledge is acquired and tested through reason, not empirically.

"harmony" by appropriating geometry to the structure of thought, we do not only "learn new things about figures" or "calculate more efficiently", but also explore the structure of our own minds in a fundamental way.

Poincaré on the other hand, defending a conventionalist view, accepts mathematics as a structure of mental concepts too, but not necessarily in a realist sense. He does not think that our "mental framework" has a particular natural equivalent in the world. It is rather a (typically human) way of describing things that could also be described differently. For Descartes, so Weil, axioms are not "true" but rather "convenient point of departure", adopted for pragmatic reasons and by conventions. Conventions are contingent, they may be changed – and so can scientific practise and the foundation it builds on. I will come back and critically analyse Weil's understanding of Poincaré's conventionalism with regards to geometry and necessary truths in the final chapter of this section.

So, with regards to Weil's remarks on geometry, we can observe that she is not *per se* opposed to the development of analytic geometry in so far as it still relies on its "traditional" fundament, advancing Euclidian Geometry in rigour but still relying on its axioms as "synthetic and analytic truths". Although analytic geometry as developed by Descartes does rely methodologically on the system's logical consistency, it still takes its truth value from what Weil takes as "correspondence with the real world", that is space as we perceive it. So, even though the analytic tradition "purified" Geometry as a science by rendering it more abstract and, in its proceedings, independent from instruments of visual representation such as drawing and measuring, it doesn't lose touch with geometrical practise and our perception of the life-world.

Looking back at Weil's critical remarks about contemporary Geometry, which "became a study of pure relationships", one cannot help but wonder at which point, according to Weil, the subject became "speculative" instead of analytic, and why.[24] As I showed above, Weil's analysis of

[24] In contemporary history of philosophy of science literature, one sometimes finds the contrasting terms "speculative" and "analytic" philosophy of science which aim at describing different 'tendencies' among schools and traditions of though in the twentieth century. The latter is mainly associated with pre-1950s "'value-laden approaches to philosophy of science', i.e., approaches that aim to offer empirical descriptions of non-cognitive (social, political, moral) values in science or normatively to appraise aspects of the scientific enterprise using non-cognitive values" in the United States. […] The [analytic, or, sometimes also called 'critical'] component was taken to include the analysis of science, including of its inferences, claims and presuppositions, and used standard philosophical techniques of analysis. Problems covered in this part of philosophy of science concerned, among other things, measurement, confirmation, scientific explanation, laws of nature, causation, probability,

Descartes indicated that the somewhat oversimplified reading that Weil is critical of abstract mathematics or the analytic tradition in general doesn't hold, since she seems to have no objection whatsoever to "purifying Geometry from its cradle". These two observations taken together suggest that there has been some kind of turning point or slide in the subject's evolution, somewhere between the Analytic but still Euclidian Geometry and the Non-Euclidian Geometries to follow. Weil herself does not put the finger on what, according to her, precisely happened in between that lies at the bottom on those transformations. This is indeed surprising and a flaw when it comes to the historical account of her argument about the "human reality" science should investigate.

In the following, I will come up with some remarks on this part of the history of Geometry on my own and see how they can be associated with Weil's ideas about metaphysics, the human mind and science as outlined above.

2.3. Non-Euclidean Geometry and the scientific world-view

It is indeed difficult to point out a single idea or movement in the History of Mathematics that can be held responsible for the transformation Geometry underwent in the eighteenth and nineteenth century. As I said before, the analytic tradition did not have Non-Euclidian Geometry as a necessary outcome, although it helped advance the subject's turning away from the Euclidean axioms. While mathematicians since Euclid occupied themselves with relationships between bodies in the physical world, analytic Geometry shifted their attention from content to form, culminating in the school of formalism as one of the most influential schools of nineteenth and early-twentieth century mathematics.

A widely-spread understanding of formalism is that of its most radical version: Formalists within a discipline are completely (and only) concerned with the (arbitrarily set) "rules of the

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reductionism, scientific realism and space and time. The speculative component of philosophy of science was (very roughly) taken to include criticizing, and building on, science in order to go beyond it and learn more about reality." (Katzav and Vaesen, 2022).

Interestingly, Weil seems to use these two terms exactly the other way round. She calls 'speculative' the kind of philosophy that is not 'doing metaphysics' and is not concerned with 'learn more about reality'. It is rather unlikely that Weil came to know the terminology presented by Katzav and Vaesen. However, it is hard to evaluate whether she uses these terms in her own, private understanding or whether they had a specific in the French tradition at her time.

game". There is no meaning apart from and no other external truth that can be achieved beyond those given rules. For example, pure formalists within mathematics claim that mathematics is no more than the symbols written down by the mathematician, which is based on logic and a few elementary rules alone. Understood in this way, mathematics is an "empty game" which "has no meaning", which is not "about anything at all" (Hersh 1997: p.42). In other words, and with an eye to the foundations of Geometry, this implies that whatever axioms are taken as primary, Euclidean or others, they are chosen at will by the mathematician – not because they have some kind of "external correspondence" or "significance", or "truth in the world".[25] What makes them true "inside the game" is their formal relationship, that is that they are consistent with one another. Weir (2015) holds, for example:

> mathematics is not a body of propositions representing an abstract sector of reality, but is much more akin to a game, bringing with it no more commitment to an ontology of objects or properties than ludo or chess.

This radical but nevertheless nowadays popular viewpoint grew over time. And we shall keep it in mind for discussing Poincaré's conventionalism, which I believe, Weil pushed too far into the formalist corner. Radical formalists, as described above, are surely guilty of Weil's accusations of science's disconnection from reality and society. At the beginning of the twentieth century, a new generation of young mathematicians, eager to turn their backs on ideology (Corry, 2003, 310) admitted, however, rather to philosophically disinterested views that were sometimes referred to by "working realism". One collective of mathematicians who officially ascribed to this view was a group publishing under the pseudonym Nicholas Bourbaki (among its members was Simone Weil's brother André Weil): [26]

> "On foundations we believe in the reality of mathematics, but of course, when philosophers attack us with their paradoxes, we rush to hide behind formalism and say 'mathematics is just a combination of meaningless symbols,' ... Finally we are left in peace to go back to our mathematics and do it as we have always done, with the feeling each mathematician has that he is working with something real. The sensation is probably an illusion, but it is very convenient." (Dieudonné, cited after Corry 2003, 310)

[25] "Chosen at will" does not necessarily mean "randomly chosen": There are of course reasons to chosen one set of axioms over another, such as convenience. I will come to this when discussing Weil's second point of criticism: instrumentalism in science.

[26] Nicholas Bourbaki was a collective of French mathematicians in the tradition of the formalist school. One of their founding members was Simone Weil's brother André Weil. It is not much known of Simone's relationship and interaction with Bourbaki's ideas, except that she attended some of the group's meetings in the 1930s and exchanged some ideas on mathematics in letters with her brother.

In his essay *Mathematics and speculation*, Bell recounts this kind of attitude more generally and at an earlier stage in form of an ironic tale about the 'religious war' in mathematics at the time (which, according to him, was based on "silly questions [that] are unanswerable").

> According to this [platonist] theory, mathematicians do not invent mathematical theorems; they discover them. One of the great surprises of my life was to find that two of the most eminent mathematicians of this or of any age believe the Platonic theory in its uncompromising entirety. After such a shock as that I was ready to believe that all the undevout astronomers I know are madder than Nebuchadnezzar ever was. […] In a debate between the two mathematicians in question, in which the topic of discussion was the Platonic theory, the argument came to a sudden and disastrous end when each, as if at a preconcerted signal, hurled at the other the epithet "theologian!" An interesting side-light on the respective leanings of those who believe the Platonic theory and of others to whom it is meaningless, appeared in a recent examination (with which I had nothing to do) given to about 300 students of science, mathematics and engineering. They were asked, "Were the theorems of elementary geometry which you studied in high school invented or were they discovered?" To a man the future scientists and engineers answered "invented." The intending mathematicians unanimously voted "discovered." Perhaps the correct answer is that silly questions are unanswerable. […] That is also the conviction of many working mathematicians. Anyhow, whether they believe in the theory of mathematical truth to which their belief in a particular "ideal theorem" commits them, or whether they boldly ignore any doubts which may ultimately nullify their conclusions, they keep on working. If the theory itself has not yet been made to work, it has the undeniable merit of making scores of productive mathematicians work who might otherwise give up in despair (Bell 1931, 206-207)

The development of Non-Euclidean Geometries in the nineteenth century were accompanied by the more moderate and charier – but at the time quite unorthodox – idea that the Euclidean view on the world, if not wrong, is potentially not the only possible view. As note Gray and Ferreirós (2021):

> for reasons which are still unclear, after around 1800 it became easier for people to imagine that Euclid's Elements might not be the only possible system of metrical geometry. Among the factors that can help explain how the unthinkable became thinkable even outside the community of mathematicians was the accumulation of theorems based on assumptions other than the parallel postulate. It would seem that the production of novel, consistent consequences of such a radical assumption, and the failure to find a contradiction, inclined some people to contemplate that there might indeed be a whole geometry different from Euclid's.

As indicated above, the historical development of non-Euclidean geometries can be attributed, if not limited, to two thousand years of unsuccessful attempts to prove Euclid's fifth ("parallel") postulate true, constituting the "biggest failure" in the History of Mathematics, or, to speak with D'Alembert "le scandale des éléments de géométrie" (cited after Gray and Ferreirós, 2021). In his attempt to shed further light on the reception of Non-Euclidean Geometry and the consequences it had outside mathematics, Marvin Greenberg resumes:

> The mystery of why Euclid's parallel postulate could not be proved remained unsolved for over two thousand years, until the discovery of non-Euclidean geometry and its Euclidean models revealed the impossibility of any such proof. This discovery shattered the traditional conception of geometry as the true description of physical space. Mainly through the influence of David

Hilbert's *Grundlagen der Geometrie,* a new conception emerged in which the existence of many equally consistent geometries was acknowledged, each being a purely formal logical discipline that may or may not be useful for modelling physical reality. Albert Einstein stated that without this new conception of geometry, he would not have been able to develop the theory of relativity. The philosopher Hilary Putnam stated that "the overthrow of Euclidean geometry is the most important event in the history of science for the epistemologist". […] The effect of the discovery of hyperbolic geometry on our ideas of truth and reality has been so profound," writes the great Canadian geometer H. S. M. Coxeter, "that we can hardly imagine how shocking the possibility of a geometry different from Euclid's must have seemed in 1820." Today, however, we have all heard of the spacetime geometry in Einstein's theory of relativity. "In fact, the geometry of the space-time continuum is so closely related to the non-Euclidean geometries that some knowledge of [these geometries] is an essential prerequisite for a proper understanding of relativistic cosmology." (Greenberg, 1993, 11-17)

What was the problem with the parallel axiom after all about? Euclid based his geometry on five fundamental assumptions, called axioms or postulates. Whereas his first four postulates[27] have always been readily accepted by mathematicians, the fifth, in the literature called the Euclidean parallel postulate, was highly controversial:

> If a straight line falling across two straight lines makes internal angles on the same side less than two right angles, the two straight lines if produces indefinitely meet on that side on which the angles are less than two right angles.

This axiom implies our common-sense idea of parallelism: If two straight lines, crossing another straight line, make internal angles of exactly 180 degrees with that line, they shall, even if prolonged indefinitely, never meet. Although this may seem "obviously true" to those who use to think of geometrical space in Euclidean terms, even Euclid was aware of the mathematically problematic character of this last axioms. Now, what makes the fifth postulate different and problematic?

Considering the axioms of geometry as abstractions from our experience, which Euclid and his followers did, the parallel postulate sticks out in so far as unlike the four others, it cannot be verified by experience at all (there is no actual way of prolonging straight lines indefinitely and see whether they meet or not, since we can only draw segments). Unlike postulate 1-4, which can be constructed by using compass and straightedge, the parallel postulate seems to require a different kind of evidence, that is logical proof: A proof that Euclid and every other

[27] The first four Euclidean postulates can be expressed informally as follows: (1) For every point P and for every point Q not equal to P there exists a unique line I that passes through P and Q. (2) any segment AB can be extended by a segment BE congruent to a given segment CD, (3) For every point 0 and every point A not equal to 0 there exists a circle with centre 0 and radius OA, (4) All right angles are congruent to each other (independent of their "location", they have the "same size"), the formulations are taken from Greenberg 1993.

mathematician “ in Greek times, […] the Islamic world, and […] the early modern West failed to come up with.” (Gray and Ferreirós, 2021). In fact, it was the consideration of alternatives to Euclid's parallel postulate arising from this history of failure that resulted in the development of non-Euclidean geometries.

The first fully mathematical descriptions of space in terms other than Euclid’s (replacing, e.g. the Euclidean parallel postulate with another axioms) was presented independently by János Bolyai and Nicolai Ivanovich Lobachevskii.

> Bolyai in his “Appendix scientiam spatii absolute veram exhibens” (1832) and Lobachevskii in his Neue Anfangsgründe der Geometrie (1835) and again in his Geometrische Untersuchungen (1840) replaced the parallel postulate with the assumption that given a line L and a point not on that line, there are many lines through the point that lie in the plane defined by L and the given point, but that do not meet the line L. Of these, as they then showed, one line in each direction is asymptotic to L, and these asymptotic lines divide the family of all the other lines in the given plane and through the given point into two families: those that meet L, and those that do not. […] All this convinced both Bolyai and Lobachevskii that the new geometry could be a description of physical space and it would henceforth be an empirical task to decide whether Euclidean geometry or non-Euclidean geometry was true. […] Those who did accept it, and they were very few before the 1860s, nonetheless may well have welcomed a better account than the one Bolyai and Lobachevskii provided (Gray and Ferreirós, 2021).

The revolution was completed in the second half of the century by Bernhard Riemann (1826–66) and his differential geometry. Although in the consecutive years the possibility of ‘translating’ non-Euclidean systems into the Euclidean language has been demonstrated (Beltrami, Klein and others), the transformation of geometry into a “hypothetico-deductive science”, consecrated by Hilbert’s *Foundations of Geometry* (1899), was now a fact. (Terzi, 2022, 147)

Although having “become a fact” to the contemporary reader, it is important to bear in mind that such attempts met at their time, as hinted by Gray and Ferreirós, significant resistance. The great hesitation on the part of leading mathematicians such as Carl Friedrich Gauß to publicly engage in discourse on Non-Euclidean Geometries[28] bespeaks the naturalness and the taken-for-grantedness with which the scientific community and intellectuals in general accepted the Euclidean worldview as the true make-up of the physical world. Although it became, as noted

[28] Although Bolyái and Lobachevsky went down in history as the daring pioneers of the developments of non-Euclidean systems, the post mortem publication of Gauss’ correspondences shows that he himself had anticipated some of Bolyai's discoveries, and had, in fact, secretly been working on non-Euclidean geometry for a long time (see Bonola, 1955).

above, somewhat easier for people after around 1800 to imagine that Euclid's Elements might not be the only possible system of metrical geometry, Gauss urged F. A. Taurinus in his letter in 1824 to "consider it a private communication of which no public use or use leading in any way to publicity is to be made".

> All my efforts to discover a contradiction, an inconsistency, in this non-Euclidean geometry have been without success, and the one thing in it which is opposed to our conceptions is that, if it were true, there must exist in space a linear magnitude, determined for itself (but unknown to us). But it seems to me that we know, despite the say nothing word-wisdom of the metaphysicians, too little, or too nearly nothing at all, about the true nature of space, to consider as absolutely impossible that which appears to us unnatural. If this non-Euclidean geometry were true, and it were possible to compare that constant with such magnitudes as we encounter in our measurements on the earth and in the heavens, it could then be determined a posteriori. Consequently, in jest I have sometimes expressed the wish that the Euclidean geometry were not true, since then we would have a priori an absolute standard of measure. I do not fear that any man who has shown that he possesses a thoughtful mathematical mind will misunderstand what has been said above, but in any case consider it a private communication of which no public use or use leading in any way to publicity is to be made. (Greenberg, 1993, 180)

Gauss' reluctance to publicly stand to his suspicions about Euclidean Geometry and his own work on further developing Non-Euclidean Geometries was probably to a great deal due to his fear of being drawn into any sort of polemic by "the metaphysicians" (also called "the Boeotians", for details see Greenberg 1993, 182). Furthermore, he seemed highly aware of what such a dramatic shift in paradigm would mean to the greater public not in possession of "a thoughtful mathematical mind" and the kind of reaction it would entail.

The changes science, and in particular mathematics, underwent in the nineteenth and first half of the twentieth century can be hardly overestimated (Stein, 1988, 238). Its rapid evolution on the methodological plane, its expansion with regards to its sub-disciplines and new alliances with other sciences are characterized by enormous success, but also shook some of its foundations as a discipline. Amazed by its achievements on the one hand, and worried about their potential implications and consequences for science in general, on the other, many mathematicians and philosophers were sceptic, if not critical of some of those latest developments (Terzi 2022, 133-38). Large parts of the hitherto cherished body of knowledge in the field that marked not only people's understanding of the discipline, education, and scientific practices, but also shaped their worldview and ideas about science in general, were gravely altered, if not discarded. In his conference on "The outlook of intelligence" (1935) the French philosopher and essayist Paul Valéry voices a widely shared concern among "traditional scientists" at the time:

> […] Paul Valéry summed up in vivid terms the epochal passage his generation had witnessed in science. […] An 'era of new facts' had opened up, calling into question the scientific image of the world and 'even our habits of thought', not to mention their practical applications, requiring an incredible 'effort of adaptation' from mankind. (Terzi 2022, 133)

In France at the time, these concerns were even more pronounced than in the German-speaking world, where mathematics as a discipline already enjoyed a much greater autonomy as a "purely mathematical community". One of the particularities of the scientific landscape we meet in end-nineteenth century France was that there was still a very close alliance – certainly much closer than it is today, and closer than it was elsewhere – between French national politics, high culture, and science. Intellectual trends, movements and problems were never merely scientific, cultural, or political. Rather, they constituted "national affairs" which were discussed among politicians, scientist and intellectuals with different focal points and varying emphases (Gutting, 2001, 7-12).

Although the young Simone Weil showed a great interest in mathematics and its history and held contact with well-known mathematicians at her time, it would be too much to say that she engaged in discourse on late-breaking publications on specialist topics in the field. She was no professional mathematician after all. It is, however, fair to say that she had enjoyed a very good general education, and, being trained as an academic philosopher in the nineteen twenties, witnessed the foundational crisis of mathematics that occupied not only mathematicians but also philosophers. This somewhat more general involvement in debates on scientific issues was rather typical for French intellectuals at her time. Vice-versa, there were also mathematicians engaging in philosophical discourse (e.g., Poincaré, Le Roy, Cavaillès).

Another aspect of French discourse at the time is, that it was, with some exceptions, rather closed and inward-looking – in a certain sense egocentric. As emphasised by numerous historians of science (Corry 2012; Gutting 2001; Ringer 1992), we meet, at the end of the 19th and the beginning of the 20th century, a relatively cohesive "knowledge society" with a high degree of shared understanding among intellectuals, strong mutual respect[29] and a small set of key topics, grounded in a common formation. This is particularly visible in French philosophy, the prestigious "crown discipline" in the "Republic of professors":

> Focused and fruitful, if not drastically creative, early Third Republic philosophy was rather like much contemporary analytic philosophy (or medieval scholasticism), though far less technical and rigorous and far more accessible to the general culture. […] Because of this lack of

[29] And not seldom family relations.

> sympathy with the dominant traditions of both Germany and Britain, French thought was very nearly autonomous during this period" (Gutting, 2001, 7)

Common key topics were secularism, human freedom, and philosophy of science. Efforts to base the Third Republic politically on a common foundation of shared values called, however, for changes at the institutional level, especially in the in the fields of education and science. The objectives were to move beyond the political and religious fragmentation of post-revolutionary French society by promoting a new, laic national identity, to overcome its old classist structure and aristocracy in favour of a new meritocratic elite, and to create the appropriate framework conditions for the rapidly evolving prestigious natural sciences. Unlike German idealists, French scientists put great emphasis on an accurate understanding and appreciation of scientific results. Nonetheless, most of them rejected empiricist epistemologies – as we meet them in the Anglo-Saxon tradition at the time – in favour of a rationalist active role for the mind (Ringer, 1992, 213-215).

Developments in the Mathematics and Physics like non-Euclidian geometry, the theory of relativity or quantum mechanics not only had those disciplines turn their back on intuition and the "common scientific worldview", but also implied a rejection of what used to be the hitherto cherished "common ground" of the arts and the natural sciences. The new theoretical body of the latter simply did not "fit" anymore with prevailing philosophical theories. Mathematics and Physics had, in the course of the revolution they underwent during that time, in a certain sense, outpaced their philosophy.

2.4. Scientific thought and ordinary thought after 1900

Weil jokingly compares philosophy's role within the world-view propagated by the new sciences to the Emperor's new clothes in Anderson's tale: No one dares to say that there aren't any, although it is in front of everyone's eyes. One would pass for a fool to speak it out loud, so we keep telling ourselves that their philosophical – or ordinary - meaning is inexpressible.

> La signification philosophique de la physique du XXe siècle, la pensée profonde qui en est l'âme, sont comme le manteau de l'empereur dans le conte d'Andersen ; on passerait pour un sot et pour un ignorant en disant qu'il n'y en a pas, il vaut mieux les donner pour inexprimables. Néanmoins le rapport qui est au principe de cette science est simplement le rapport entre des formules algébriques vides de signification et la technique. (Weil, 1966, 136)

According to her, the new sciences have no relationship with what is "of meaning" to ordinary people or even philosophers. Their theories do not tie in any way into the landscape of our existing views about the world or connect with anything "of value" to society in general. After all, what does Einstein's theory of relativity tell us about time? Or quantum mechanics about work? Those theories have meaning only in the formal sense or with regards to technical applications, so Weil.

> La science du XXe siècle, c'est la science classique après qu'on lui a retiré quelque chose. Retiré, non pas ajouté. On n'y a apporté aucune notion, et surtout on n'y a pas ajouté ce dont l'absence en faisait un désert, le rapport au bien. On en a retiré l'analogie entre les lois de la nature et les conditions du travail, c'est-à-dire le principe même ; c'est l'hypothèse des quanta qui l'a ainsi décapitée. Les formules algébriques auxquelles se réduisait, vers la fin du XIXe siècle, la description des phénomènes, signifiaient cette analogie du fait qu'à chacune d'elles on pouvait faire correspondre un dispositif mécanique dont elle traduisît les rapports entre distances et forces ; il n'en est pas ainsi pour une formule faite d'une constante et d'un nombre, une telle formule ne peut rien exprimer qui se rapporte à la distance. […] Pareille chose une fois admise, la physique devient un ensemble de signes et de nombres combinés en des formules qui sont contrôlées par les applications. Dès lors quelle importance peuvent bien avoir les spéculations d'Einstein sur l'espace et le temps ? Les lettres des formules qu'il traduit par ces mots n'ont pas plus de rapport avec l'espace et le temps que les lettres hν avec l'énergie. (Weil 1966, 102)

Twentieth century science, the massive growth of its theoretical body and applicability notwithstanding, is, according to Weil, somewhat "less" than classic science. Science may have gained predictive success as well as advancement in its measuring instruments and technology. However, on a different level, so Weil, it has not gained but actually lost something compared to classical and modern science: it's intelligibility. It has lost its potential for analogy with human life and experience.

Moreover, besides this loss, we missed to add something important – something that according to Weil should be part of science just as it is part of politics and societal discourse: existential human concerns and values that are interwoven with physical processes, but which were never considered as important as natural laws or mechanical operations. According to Weil, science missed out to make its methodological and technical revolution also one of social progress.

> La rupture entre la science du XXe siècle d'une part, la science classique et le sens commun de l'autre, était totale dès avant les paradoxes d'Einstein ; une vitesse infinie et mesurable, un temps assimilé à une quatrième dimension de l'espace, ne sont pas choses plus difficiles à concevoir qu'un atome d'énergie ; tout cela est également impossible à concevoir, quoique très facile à formuler, soit dans le langage algébrique, soit dans le langage commun. Quoique le bien fût absent de la science classique, aussi longtemps que l'intelligence à l'oeuvre dans la science fut une forme seulement mieux aiguisée de celle qui élabore les notions de sens commun, il y eut du moins quelque liaison entre la pensée scientifique et le reste de la pensée humaine, y compris la pensée du bien.

According to Weil, classical science (and with that she means science before the nineteenth century), could be understood, in a certain sense as “common sense elaborated”. There used to be, so Weil, a connection, albeit an indirect one, between scientific thought, our ordinary way of reasoning (“la pensée humain”) and moral and political concerns (“la pensée du bien”). The latter was surely the least pronounced, but since political and civil thought have developed considerably in this respect throughout modernity, it seems absurd that science remains completely detached from it. Classical science, although slow, inexact and to some extend obscure was, so Weil, limited and exhausting in many ways. However, despite, and in a certain sense also because of that, it was a fair representation of our thinking processes and capacities, our experience as “parts of the universe”, and of work. It left us sometimes puzzled, confused and disorientated in the face of certain events, but there was at least some connection between science and the rest of human thought.

Nowadays, that is in contemporary science, Weil observes a new “desire” which she describes as a sort of fetish among scientists and also some philosophers: Tired of tedious, slow, and “uncertain” old science, they triumphed at the idea of a fundamental incompatibility between reason and science; and of course, it was reason that was wrong. One essential feature of scientific thought becoming incommensurable with ordinary thought is the new sciences rejection of rationalist epistemologies in favour of empiricist ones.

> Mais même cette liaison si indirecte fut rompue après 1900. Des gens qui se disaient philosophes, fatigués de la raison, sans doute parce qu'elle est trop exigeante, triomphèrent à l'idée d'un désaccord entre la raison et la science ; bien entendu, c'est à la raison qu'ils donnaient tort. […] Ce qui leur procurait une joie particulière, c'était de penser qu'un simple changement d'échelle apporte dans les lois de la nature une transformation radicale, tandis que la raison exige qu'un changement d'échelle change les grandeurs, non les rapports entre grandeurs ; ou encore ils étaient heureux de penser que les nécessités regardées longtemps comme évidentes deviennent, quand des instruments meilleurs permettent de pénétrer plus avant, grâce aux atomes, dans la structure des phénomènes, de simples à peu près. Leur joie n'était pas seulement impie, étant dirigée contre la raison, elle témoignait aussi d'une incompréhension singulièrement opaque. (Weil, 1966, 110)

The recent developments in mathematics and physics threw over the very tenants of what human beings experience as “true” and “real” in ordinary life. Consequently, scientific worldview became not a more refined version, but an alternative in a strong sense to our conventional understanding of things.

This was not only recognised by Weil. Although most physicists and mathematicians were amazed by the progress made in the blink of an eye in world history, at least some saw a certain inconvenience in this counter-intuitiveness. This becomes visible from attempts to counter the “counter-intuitiveness” argument by claiming that intuition is contingent and mostly based on conventions. This brought along the idea that our worldview, just like models in physics or axioms in mathematics, could be – at least in theory - manipulated, adjusted and relativized according to whatever new measure is being introduced.

Weil, however, was convinced that our experience of the world would not “follow” such severe intellectual adjustments of the scientific worldview in the sense that it would not make us see ordinary things in a fundamentally different way. She did not believe, for instance, that certain subjective, *a priori* conditions structuring human experience could be “remodeled”. Nor did she think we should easily discard concepts that have an important meaning in our live. In fact, she advocates rather for adjusting our theoretical models in light of the constraints posed by the latter.

This has to do, on the one hand, with her understanding of “necessity” with regards to the laws of nature. In neo-Kantian fashion, Weil believes that (i) scientific laws do involve necessity, but that (ii) this necessity is based “not on (purely metaphysical and hence inaccessible) relations between universals, but rather on certain subjective, a priori conditions under which we can experience objects in space and time” (Watkins & Stan 2014).

Additionally, there are body-related and psychological conditions that determine our experience. Given our biological make-up, we will, for instance, always perceive heat and movement as two things different in kind, not in degree. Our experiences of, for example, work or effort could never match their purely “scientific” description as relations between natural forces, because for humans, they also involve things like aspirations, hopes and suffering.

Scientists seem to believe, so Weil, that by establishing more accurate experimental settings, we can force a “deeper” structure of reality to “reveal itself”. There seems to be the dream out there that empirical research would provide, by means of exact measurements in a controlled setting, combined with rigorous logical reasoning, access to objective truth and therefore render obsolete “metaphysics”. Leaving aside the fact that Weil does not seem to believe much in the success of the new sciences in "discovering hitherto unknown truths of the universe" with their new methods, she at least does not see how these new, counter-intuitive truths would be of value or meaning outside the realm of science. Why should we think of our bodies as an accumulation of atoms? Even if we try to do this, she says, we do not experience ourselves any differently.

> L'étude des atomes correspond dans la science, non seulement à un changement d'échelle, mais aussi à tout autre chose. Si l'on imagine un petit homme, semblable à nous, de la dimension d'une particule atomique, vivant parmi les atomes, ce petit homme, par hypothèse, sentirait de la chaleur, de la lumière, des sons, en même temps qu'il verrait et accomplirait des mouvements ; mais, dans le monde d'atomes conçu par les physiciens, il n'y a que des mouvements. En passant de notre monde à celui des atomes, on transforme, entre autres, la chaleur en mouvement ; et pour notre sensibilité il y a une différence non de grandeur, mais de nature entre mouvement et chaleur. (Weil, 1966, 110)

What results, however, from such "new truths" is that it sharpens the divide between the ordinary and the scientific worldview, and consequently also between the savant and the ordinary person as epistemic agents. Furthermore, it reduces human beings to their "measurable" biology and positions them within a system that has no concern for their feelings, needs and values but rather takes them as "piece of hardware".

According to Weil, there always has been a certain tendency in human beings to imagine themselves as being parts of a closed, limited, rigorously defined universe, where there is a perfect connection between deeds and consequences. We succeed perfectly in creating such situation in certain games where all the possibilities are countable or at least even finite, such as in dice and card games, or in chess.

> L'homme a toujours tenté de se donner à lui-même un univers fermé, limité, rigoureusement défini ; il y réussit parfaitement dans certains jeux où tous les possibles sont en quantité dénombrable et même finie, tels que les jeux de dés, de cartes, d'échecs. Les carrés blancs et noirs de l'échiquier, les pièces du jeu, les mouvements possibles de chacune en vertu des règles étant en nombre fini, et une partie d'échecs étant quelque chose qui s'achève tôt ou tard, toutes les parties d'échecs possibles sont en nombre fini, quoiqu'une telle énumération soit pratiquement beaucoup trop compliquée. […] La complication est essentielle à l'intérêt, et l'on ne jouerait pas si l'on pouvait avoir en fait dans l'esprit toutes les parties possibles ; mais quoiqu'elle dépasse la portée de l'esprit humain comme si elle était infinie, elle est finie pourtant, et cela aussi est essentiel au jeu. (Weil, 1966, 117)

Of course, bearing in mind all possible moves, albeit finite, still exceed our mental capacities. This makes the game complicated, and therefore interesting, but, unlike the universe, it is still an essential feature of the game that it is "finite" in its possibilities.

> Le joueur se donne un univers fini par des règles fixes qu'il impose à ses actions, et qui chaque fois qu'il va jouer lui donnent seulement le choix entre un petit nombre de possibles ; mais aussi

> par des objets solides, qu'il est porté à imaginer comme immuables, quoique rien ne soit immuable en ce monde, et qu'il décide de considérer comme absolument immuables. S'il en est empêché à certains moments par le spectacle d'un pion d'échecs brisé, d'une carte déchirée, il appelle cela un accident, et il y remédie par un nouvel objet, substitué à celui qui a changé et considéré comme ne faisant qu'un avec lui. Est nommé accident toute intervention de l'univers dans le système clos du jeu, et les accidents sont négligés par le joueur ; le jeu est ainsi le modèle de la physique. […] Dans ces jeux aussi des objets solides dont la forme est regardée comme immuable, des règles fixes imposées aux mouvements et limitant les possibles, quoique l'ensemble des possibles y ait la puissance du continu, déterminent un système clos, et les accidents sont négligés. (Weil, 1966, 117)

This is also so because we take certain things for granted in our games without thinking about it, like the wholeness of our playing pieces: they are simply tokens. If we find ourselves confronted, for example, with a broken chess pawn, we call it an accident and substitute it with a new piece we take from outside into the game. So, the game does not depend, in this sense, on its "hardware". Also in physics, just like in games, we call any intervention of the universe from outside into the closed system an accident, and accidents are neglected.

> Les accidents peuvent être négligés dans les jeux, précisément parce qu'il s'agit de jeux. Ils sont plus malaisés à négliger dans le travail, où la faim, le froid, le sommeil, le besoin fouettent sans cesse, où les résultats sont ce qui importe, où un accident rend les efforts vains, cause le malheur ou la mort. (Weil, 1966, 118)

However, accidents in games can be overlooked or neglected precisely because they are games. They are, so Weil, much more difficult to neglect in the lifeworld where we are constantly shaken by hardships and needs like hunger, cold and sleep. In the lifeworld, unlike in games, the results are what matters. An accident, however small, can make all our efforts in vain, cause harm or death. In the real world, unlike in games, we are not and should not be open and unbiased as to the result, since it is the latter that makes all the difference. We often cannot, like in a game, make a step undone or replace a broken piece with a spare part "from outside", because certain parts that we take as "solid base" – like our bodies – cannot be substituted.

Let us now sum up Weil's remarks so far with regards to her general argument that we need metaphysics and that we should take certain parts of "human reality" as fundamental for our metaphysics in science. First, however precise our instruments of measurement or rigorous our logical frameworks may be, there always remains something inexplicable about the world. Not because the world is a mystery in itself, but because our human minds and bodies are limited in both extent and perspective. "Reason" as a more refined form of ordinary thinking is not able to account for all there is "out there", but it is, at least in principle, able to account for important aspects of human reality. It is able to describe this reality, being somewhat imprecise, ambiguous and vague, as such. Philosophers advocating positions like logical positivism seem to think that banishing everything but logic and systematic empirical observation from science will allow us to “go beyond” the capacities of our limited mind, to find truths more objective and more fundamental and to erase all vagueness and mystery from our lives.

For one thing, Weil does not seem to believe much in the “dream” of logical positivism with regards to its own mission. She does not think that empirical observation will obviate the need for metaphysics. Neither does she believe that metaphysics is just a matter of convention – at least not for human beings. Whatever a new scientific theory may rely on or propagate as “fundamentally true”, it will never alter, for example, the way in which we perceive time, space, temperature, or grief.

Her main point is, however, that the idea of a “supra-human science” which is no longer limited by “non-scientific issues” such as intuitiveness, applicability or connection to common knowledge removes some of the most important aspects of human lives from the list of “things there really are”. This has harmful consequences because such approaches dehumanise our most important body of knowledge. In her view, humans are “playing animals” and it is natural to come up with mental images of the environment as closed systems in order to achieve something concrete or gain orientation. Those images have a certain similarity with games, but they should rather be regarded as metaphors than as “models of the universe”. Science as a formalised game, so Weil, ignores the most important parts of human reality, like wholeness, well-being, dignity, and justice. It promotes and forces upon us a world-view that not only runs counter to how we ordinarily think and perceive, but it also renders us “chess pawns” in a game full of accidents. Contemporary science may yield results that, according to the truth conditions within the game, are “true”, but they are entirely different from what is “true” in the human world – in our existential experiences and needs. Misery and suffering are not “relativistic concepts” for the human beings who experiences them; they are, in a certain sense, “undeniable” and “primary”.

2.5. A closer look on conventionalist truth

Finally, I will take a closer look on Weil's understanding of conventionalism with a focus on necessary – here, mathematical – truth, as brought up by Henri Poincaré. On the one hand, this allows us to gauge Weil's understanding of Poincaré's view against the view he presents himself. I intend to show that albeit "guilty" in the eye of Weil's critique in general, the latter's view was much more complex and nuanced as recognised by Weil. For instance, Poincaré was not an anti-realist, and a "conventionalist" choice of axioms meant by no means an arbitrary one. In my view, Weil's critique is more a critique of an over-generalising reception of his conventionalism than it is of his own account. If reading Poincaré more carefully, she might have been able to connect to some of his ideas. His library analogy, for instance, bears some potential for a view of reality with an eye to human needs. Nevertheless, it remains true that mathematics, and maybe most of all Geometry, became a "language" in the twentieth century, and "the most general of all".

It is important to note that Poincaré's understanding of necessary truth cited by Weil is only a small part of his conventionalist position – it mainly concerns methodological issues in science more generally. The latter aspect shall be brought up here only insofar as it is necessary to understand Poincaré's conventionalist conception of "truth" of axioms in geometry.

In the context of the scientific method, Poincaré's "conventionalism' is, for the most part, associated with the notions of "underdetermination" and "equivalent descriptions". Both concepts result from the idea that some – but not all – crucial theoretical questions are underdetermined by empirical fact (in the sense that sometimes there may be no "fact of the matter"), leading to the conclusion that scientific method leaves room for discretion. The idea is that

> [when] theories are underdetermined by fact, there may be alternative theories that differ in their content, or might even be inconsistent with one another, but are, nevertheless, equally satisfactory in terms of the predictions they yield. Such theories are logically distinct but empirically equivalent. Underdetermination and empirical equivalence are two aspects of the same situation — the failure of the totality of empirical constraints to yield a single theory. […] Underdetermination by a finite set of observations—the garden variety of the inductive inference— leaves room for determination by further data. When theories are empirically equivalent, however, no further data can decide between them. Does it make sense to consider only one of the empirically equivalent alternatives as true? The conventionalist answers in the negative, claiming that in such cases there is no fact of the matter; equivalent theories have the same veridical status. (Ben-Menahem, 2016)

A prime example Poincaré brings up for conventionalism in mathematics is that of the underdetermination of geometry by observation (see, for instance, Poincaré 1902, 52), where he holds that no experiment could decide between different geometries of constant curvature, which is why theories bases on different geometries of this kind are empirically equivalent. As pointed out by Ben-Menahem, Poincaré – just like Hilbert – distrusted intuition as a guide to truth. But why is that so?

As aforementioned, the development of Non-Euclidean Geometries and the critics about its counter-intuitiveness that followed gave rise to the idea that "intuition", understood as "*a priori* framework that allows us to make sense of sensual perception" was not *a priori* after all, but another convention. Explanatory attempts differed in both content and extent. Poincaré himself commented on this at length, coming up with a theory of perception on his own. It would exceed the scope and aim of this chapter to retell it in detail, so I will quickly summarise his position. In *Science and Hypothesis*, he presents the reader with a thought experiment that should illustrate his basic idea about the relationship of intuition and perception:

> Beings whose minds were made as ours, and with senses like ours, but without our preliminary education, might perceive from a suitably-chosen external impressions which would lead them to construct a geometry other than that of Euclid, and to localise the phenomena of this external world in a non-Euclidean space, or even in a space of four dimensions. As for us, whose education has been made by our actual world, if we were suddenly transported into this new world, we should have no difficulty in referring phenomena to our Euclidean space. Perhaps somebody may appear on the scene some day who will devote his life to it, and be able to represent himself the fourth dimension. (Poincaré 1902: 51)

There are two essential points in this quote: First, our ability or disposition to perceive objects in Euclidean space is no inborn quality, but "a matter of education". We are not born engaging with the world in terms of this framework, we *learn* to do so. With this statement, Poincaré does not yet deny that our sensual perception is pre-structured. What he says is that this is not necessarily the Euclidean framework that must be employed. That everyone does so is a contingent fact in our "actual world".

Second, our "choice" of Euclidian geometry is not determined by some properties of space or the objects of our perception. Even in a world that is entirely different from ours in this respect, we should be able to "use" our Euclidean framework to conceptualise phenomena there. So, to sum the first two points: Three-dimensional space and Euclid's axioms are, according to Poincaré, a feature of our understanding, a particular way of making sense of perception. They have, however, nothing to do with the space and the objects surrounding us. Nor have they anything to do with our sensory abilities – they are learned, and, as Poincaré suggest, could even be changed at will and at a later point in life.

Indeed, the phrasing “Perhaps somebody may appear on the scene some day who will devote his life to it” suggest that Poincaré was aware that such a “change of perspective” or “change of world-view” would require much more than merely the will to do so and a new set of axioms ready to be applied. So, based on these assumptions, he concludes that since there are different geometries that can be used by mathematicians (and could, at least perhaps be used by ordinary people), the axioms of each of them cannot be seen as necessary truths whose negations are inconceivable. Instead, axioms should be construed as definitions—implicit definitions. As such, they are not only denied the status of necessity but also the status of truth.[30] This is how Poincaré arrives at the conclusion that

> They [the geometrical axioms] are conventions. Our choice among possible conventions is guided by experimental facts; but it remains *free*, and is only limited by the necessity of avoiding every contradiction, and thus it is that postulates may remain rigorously true even when the experimental laws which have determined their adoption are only approximate. In other words, the axioms of geometry (I do not speak of those of arithmetic) are only definitions in disguise. What, are we to think then of the question: Is Euclidean geometry true? It has no meaning. We might ask if the metric system is true, and if the old weights and measures are false; if Cartesian co-ordinates are true and polar co-ordinates are false. One geometry cannot be more true than another ; it can only be more convenient. (Poincaré, 1902, 50)[31]

I should add that Poincaré, being first of all a professional mathematician, has his main interest in the “realm of mathematics” and “realm of science”, rather than in the “realm of ordinary experience”. We have noticed that with his thought experiment and his half-hearted remark that maybe, perhaps, one day, there could be someone to makes it his his-life ambition to see the world in terms of different geometrical axioms. This becomes even clearer in the quote above, where he talks about “experimental facts” and “experimental laws” that guide (although not determine!) our choice of a “convenient” geometry. The latter, even though clearly addressing primarily an empirical scientific setting, include, at least theoretically, also the setting of our

[30] If “truth” refers to anything outside the particular axiomatic system.

[31] Accordingly, Weil quotes Poincaré: « Au lieu d'être reine de la science, la mathématique n'est plus qu'un langage ; à force de dominer, elle est réduite à un rôle servile. C'est pourquoi Poincaré a pu dire, par exemple, que les géométries euclidienne et non euclidienne ne différent que comme un système de mesure d'un autre. < Que doit-on penser, dit-il dans La Science et l'Hypothèse, de cette question : la géométrie euclidienne est-elle vraie ? Elle n'a aucun sens. Autant demander si le système métrique est vrai et si les anciennes mesures sont fausses ; si les coor-données cartésiennes sont vraies et si les coordonnées polaires sont fausses. Une géométrie ne peut être plus vraie qu'une autre, elle peut seulement être plus commode. > Ainsi, selon le témoignage du plus grand mathématicien de notre siècle, la mathématique n'est qu'un langage commode. »

ordinary life-world. With regards to the latter, Poincaré acknowledged the choice of "Euclidean axioms" as the "most convenient", now and in general:

> Now, Euclidean geometry is, and will remain, the most convenient: 1st, because it is the simplest in itself, just like a polynomial of the first degree is simpler than a polynomial of the second degree ; 2nd, because it sufficiently agrees with the properties of natural solids, those bodies which we can compare and measure by means of our senses. (Poincaré, 1902, 50)

What we can see here is that Poincaré, contrary to Weil, does not connotate "convenient" negatively: Instead of calling it "the most convenient", he could have just as well said that it is the most rational, intelligent, appropriate or simply "right" choice to make in this particular context. Euclidean geometry is the best way of describing our world. And, what is more:

> Different geometries (of constant curvature), although seemingly incompatible with one another, are in fact equivalent, for all of them can account for the same mathematical *facts*. They differ only in the way they describe the facts. [...] The choice between such alternative sets of axioms does not confer truth; it is a choice between ways of describing truth. Clearly, a choice of a mode of description can be recognized as conventional without offending against the realist conception of truth. (Ben-Menahem, 2016)

What remains, however, true is that by taking geometry as a matter of convention and making conventionalism merely about "modes of expression", one indeed "reduces" mathematics to a "language", as Weil correctly points out. Poincaré's position does not, as noted by Ben-Menahem, rule out epistemological realism, and even less realism in ontology. Note here again the key role the notion of *facts* ("the same mathematical facts") plays in this context: without invariant facts, or "fixed content", the equivalence thesis could not be formulated. Nevertheless, it separates the *Geometrical Space* from the *Representative space*, as Poincaré calls them, along the same line as it separates the physical world from the language describing it. Although keeping up realism, it makes them two different realms, both in ontology and in truth-value.[32] In this context, he used the analogy of a library: Whether the library has a certain book is a matter of objective fact, but the catalogue of the library can be variously organized. As long as a catalogue has the correct information about the books, there is no right and wrong, only convenience, with regard to the organizing scheme (after Ben-Menahem, 2016, summarising Poincaré's analogy in 1902/1952, 144).

Weil, when quoting Poincaré, remarks disapprovingly that "thus, according to the greatest mathematician of our century, mathematics is only a convenient language" and "instead of

[32] Here we see the influence of the "semantic tradition" mentioned by Corry (see chapter 2.1) that "exhausted" in a certain sense, Kant's idea of a priori knowledge.

being queen of the sciences, mathematics is no more than a language; for all its efforts to dominate it is reduced to a servile role". This remark is, of course, an over-generalisation, and, as we have seen, false: Poincaré was very explicit about limiting his conventionalism to geometry and not extending it to other branches of mathematics, such as arithmetic.

In the second remark, labelling mathematics the "queen of the sciences", Weil quotes Gauss (also nicknamed *Princeps mathematicorum* or Prince of Mathematics), who allegedly said that "Mathematics is the queen of the sciences and number theory is the queen of mathematics".[33] What he probably mainly meant to express was the traditional (and somewhat unexciting) view that mathematics is the science of quantity, and that mathematics plays a key role in other sciences. It is rather unlikely that he additionally meant to make a more concrete philosophical claim about the nature of mathematical truth or the particular relationship it has with other sciences. Gauss did not concern himself much with philosophical questions, and he did not have a high opinion of philosophers in general.[34]

The question whether mathematics was the "queen" rather than "servant" or "handmaid" (Bell, 1937) of the sciences, comes, in my opinion, mainly down to the attitude one adopts towards its "instrumental value" to the sciences and one's view of, e.g., mathematical physics, rather than to actual differences in view on what makes that relationship. Although Weil and Gauss were neither the first nor the last to attribute such anthropomorphic roles to mathematics, I could not find any 'substantive' arguments on why it should be queen rather than servant and how this makes an essential difference. As notes Atiyah in his essay *Mathematics: Queen and servant* (1993), they rather highlight different aspects of the relation like elegance, beauty and formal authority coming from the queen, on the one hand, or the utility, flexibility, and reliability of a good servant, on the other.

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[33] I was not able to find this quote or the context in was written or said in. It would be interesting to see whether Gauss elaborated on this, although it seems rather unlikely that there was much more to it (from a philosophical point of view). He did, however, commit explicitly to the traditional view that mathematics is the science of quantity (see e.g., his *post mortem* published essay entitled *On the metaphysics of mathematics* (1929), see also Gillies, 1999).

[34] In a letter to H.C. Schumacher (1 November 1844) he remarks: "That you believe a philosopher *ex professo* to be free of confusion in concepts and definitions is something I find almost astonishing. Nowhere else are they more common than in philosophers who are not mathematicians, and Wolff was no mathematician, though he put together many compendiums. Just look around at the modern philosophers, at Schelling, Hegel, Nees von Esenbeck and consorts—don't their definitions make your hair stand on end? Read in the history of ancient philosophy what the men of the day, Plato and others (I except Aristotle), gave as explanations. And even in Kant matters are often not much better; his distinction between analytic and synthetic propositions seems to me to be either a triviality or false" (Gauss 1863-1929, Vol. xii, pp. 62-3, *cited after Bragg Ewald 1996: 293*)

> As with language, where thought and word interact with one another, so science and mathematics interact with each other. It is difficult to separate contents and framework: each influences the other in a complex symbiosis. It is for this reason that I have no difficulty in describing mathematics as the language of science. Some of my colleagues might feel that this gives mathematics too humble a status, that of the "servant," and they would prefer the loftier position of the "queen" from whom all authority and beauty emanates. But if we reflect on the power of words, and the role they play in organizing, refining, and transmitting ideas, then we see that the role is an honourable one. Ideas without words remain vague and ineffective, and science without mathematics remains similarly handicapped (Atiyah 1979: 529-30)

What is more, the history of science clearly shows that mathematics' interaction with sciences like physics was neither new nor a one-sided business.[35]

One last point I will discuss with regards to Poincaré's conventionalist approach to the status of geometrical axioms has to do with this so called "formal authority" previously ascribed to the queen mathematics: That is (logical) consistency. We have already heard from Poincaré in passing that "our choice among possible conventions […] is only limited by the necessity of avoiding every contradiction". This last bit of his remark, introducing consistency as a necessary criterion for any set of axioms, merits more attention than it has so far received. Indeed, it gave rise to a very interesting controversy between Frege and Hilbert, and the other between Russell and Poincaré, about what makes axioms true.

As pointed out by Ben-Menahem, Poincaré and Hilbert largely agreed on the status of axioms in geometry. True, Hilbert did not speak about "conventions", but there is no substantial difference between their views in this respect.[36] Both understood axioms as implicit definitions,[37] that is conditions "picking out" the mathematical entities and relations that satisfy them. What constrains their choice is only consistency. Both stated enthusiastically the latter as "the only criterion for truth and existence":

> In his correspondence with Frege at the turn of the century Hilbert says, "If the arbitrarily posited axioms together with all their consequences do not contradict one another, then they are true and the things defined by these axioms exist. For me, this is the criterion of truth and existence" (Hilbert to Frege, in Frege 1971, 12). Poincaré is no less emphatic: "In mathematics the word 'exist' can have only one meaning: it means free from contradiction" (1905–6; Ewald 1996,

[35] A concise and informative historical overview on the relationship of Mathematics and Physics is provided by Atiyah (1993).
[36] This point is convincingly made by Ben-Menahem (2016).
[37] The novel account of axioms as implicit definitions gave, however, rise to fierce controversies, one between Frege and Hilbert, and the other between Russell and Poincaré, on the semantic freedom allowed by the new conception of axioms.

> 1026). And similarly: “The mind has the faculty of creating symbols. . . . The only limit to its power is the necessity of avoiding all contradiction” (Ben-Menahem 2016)

Frege and Russell, on the other hand, felt this was a bit too much freedom, in a double sense: For one thing, there was disagreement on the relationship between axioms and mathematical entities. Although Poincaré, as we have seen, acknowledges the existence of “mathematical facts”, he and Hilbert saw it as a great merit of their account that not only could different sets of axioms be used to describe the same facts, but also that the same set of axioms could be used to describe a great – or even infinite – variety of kinds of entities. This presupposes, of course, that the terms appearing in these “implicit definitions” could be variously interpreted.

> Frege and Russell, […] saw the possibility of such diversity as a major flaw of this conception of axioms (Russell 1899; Frege 1971). On the traditional account that Frege and Russell sought to retain, axioms expressed eternal truths about well-defined entities given to us by intuition. On this understanding, a reinterpretation of the axioms so as to give them a different meaning and make them applicable to different sets of entities could only be seen as a serious confusion. (Ben-Menahem 2016)

For another, Frege and Russell were alarmed by Poincaré’s proclamation that consistency would function as a truth-maker, not only within language, but in a realist understanding. This is, at least historically speaking, indeed misleading since Poincaré’s whole point in construing axioms as conveniently chosen definitions was that, as such, they could be neither true nor false (but, as he kept repeating, “merely conventional”). In reply to Hilbert, Frege, quite alarmed, pointed to this slide from “non-contradictious to true”:

> If a general proposition contains a contradiction, then every particular proposition included under it will do likewise. Therefore from the consistency of the latter we can infer that of the general one, but not vice versa. . . . But can we conclude still further that the . . . [general theorem] is therefore true? I cannot admit such an inference from consistency to truth. *Presumably you don’t mean it in that way either*. . . . In any case, a more precise formulation is needed. (Frege to Hilbert, in Frege 1971: 20–1, cited after Ben-Menahem 2016)

As pointed out by Ben-Menahem, speaking anachronistically, “we could say that the insight underlying their position was that a consistent set of axioms would have a model and the axioms would then become true in the model. But this model-theoretic language was not yet available”. It seems thus, rather a formulation that “lack[s] precision” and is “not to be taken literally”, as pointed out by Frege, rather than a clairvoyant inside or a conscious commitment to formalism. So, to sum up the controversy between the two parties with regards to consistency (assuming that Poincaré’s and Hilbert’s remarks on consistency as a truth-maker was somewhat of a rhetorical overstatement):

> Taking axioms to be self-evident intuitive truths, Frege and Russel argued that truths cannot contradict one another and that it is thus the truth of the axioms that guarantees their consistency. Hilbert and Poincaré, on the other hand, distrusted intuition as a guide to truth. When putting forward a set of axioms, one cannot know by mere intuition whether they are indeed true and what kinds of entities they are true of. If axioms were inconsistent, however, they could not possibly be true; they would have no application whatever. A proof of consistency was therefore required at least as a necessary criterion for the admissibility of axioms. (Ben-Menahem 2016)

Confusions and exaggerations of this kind (construing consistency as truth-maker rather than as a admissibility criterion) have certainly contributed to the impression among philosophers like Simone Weil that science has taken on a game-like character.

3. Science's disconnection from society

What I outlined as the "Science's disconnection from society" is closely related to Weil's first point – its disconnection from reality. As we have seen, Weil thinks that contemporary science is "speculative" and no longer in accordance with intelligibility and life-world experience. More concretely, the conditions required for beliefs to constitute scientific knowledge, such as truth and justification, have become entirely different to those of "ordinary thought". Science is no longer derived from foundational beliefs about "what there is" but requires only a coherent set of beliefs (the consistency criterion mentioned above). Weil's criticism partly targets this way of "doing science" per se. What she finds, however, most problematic is the attitudes some scientists (e.g. Poincaré) display with respect to science's role and function in society, proclaiming that "if science cannot be done for science's sake, there can be no science at all". Scientific activity should by no means be influenced, corrupted, or constrained by "external" interest, be they political, economic, or intellectual in a broader sense. In their view, (empirical) scientific enquiry does not need "external criteria" or values to guide it, since it has its own, joint-carving criteria (e.g., simplicity).

First, Weil think that these claims are, if not in contradiction, at least in strong tension with a conventionalist view of truth as presented by Poincaré (discussed above). If scientific theories are neither true nor false, but simply convenient ways of describing things, what is it then that makes one more convenient than another, if not external values/criteria like, e.g., applicability? Scientists, Weil observes, often justify their methods with the argument that they "work" in a pragmatic sense, e.g., that they yield technical and predictive success. Doing so, she argues, they reduce science to a "mere tool", put into the service of the industry. More importantly, however, how can they then still claim that science should be done for its own sake and independent of practical needs? Weil remarks:

> Une autre contradiction concerne le rapport de la science et des applications. Les savants modernes, considérant, comme, semble-t-il, il leur convient de le faire, la connaissance comme le plus noble but qu'ils puissent se proposer, refusent de méditer en vue des applications industrielles, et proclament bien haut, avec Poincaré, que, s'il ne peut y avoir de Science pour la Science, il ne saurait y avoir de Science. Mais c'est à quoi semble mal convenir cette autre idée, que la question de savoir si telle théorie scientifique est vraie n'a aucun sens, et qu'elle n'est que plus ou moins commode. (Weil, 1966, 13)

Furthermore, Weil disagrees with these views, and she thinks they have harmful implications with regards to the role science occupies in society. In this chapter, I will take a closer look on Weil's understanding and opinion of the so called "science for science's sake attitude" (short *SfSS*) as well as her own ideas on science's role in and value for society. The SfSS dictum does not denote an exclusive position of one person but is a kind of attitude that has grown over time in the context of social and general intellectual debates, such as the so-called bankruptcy of science debate.[38] Although the arguments of its advocates are more homogeneous than those of its opponents, SfSS is, from a historical point of view, more of a slogan than a fixed and differentiated conception of science.

In her writings on science Weil refers to many people, but one name reappears repeatedly, especially when she develops her general views on the value or "purpose" of science: That is Henri Poincaré. The latter, whom Weil calls "the greatest mathematician of the century", has, besides his numerous contributions to the field of mathematics, also published on philosophy of science more generally.

However, Weil's engagement with his arguments remains indirect in so far as she rarely cites directly from a particular source (the science for science's sake slogan appears, for example, throughout numerous of his writings). It is therefore sometimes difficult to evaluate to what statements of Poincaré's she is exactly referring to. Furthermore, Poincaré and Weil, although revolving around the same issue – namely whether science should be pursued independently from societal needs and values – address it from different standpoints, that is with different interests and foci.

For one thing, Poincaré, although broadly interested in philosophical debates, was not a militant in the sense that he never actively campaigned for science to play this or that role in society. His philosophical writings were mostly reactions and in some cases defences, either to other thinkers attacking him directly, or, more often, to public polemics and schools of thought that tried to misrepresent or instrumentalise statements he and like-minded colleagues had voiced. The historical context of his more general remarks on science[39] was the French version of the

[38] The historical context of the bankruptcy of science debate is not essential part of my argument here. A good overview on the issue is provided, e.g., by MacLeod (1982).
[39] With "more general", I mean philosophical remarks on science in general (rather than discussing specialist issues of mathematics or physics).

“bankruptcy of science” debate and its revival in the interwar period. In this debate, intellectuals critically commented on the place the science should occupy in society and with regards to the arts. One popular position that was asserted with varying emphasis and interest was that scientific inquiry should be regulated by more general concerns. Poincaré’s main ambition with regards to those criticisms to dismiss them and secure science’s autonomy.
For another, Poincaré’s interest, when concerned with issues like the relationship between science and politics and society, reached as far as they could be connected to philosophical questions on inner-scientific issues.

Weil, on the other hand, although genuinely interested in science, addresses those issues mainly in connection to more general concerns, like science’s relationship with the human mind, social justice, and education. She did not pick a side in the bankruptcy debate or engaged in widely-spread polemics but was primarily concerned about the most recent developments in the sciences and how they would affect ordinary people’s life. Being not only a philosopher but also a political activist and teacher, her account on the relationship between science and society focuses more on the latter than on the former. When commenting on some of Poincaré’s remarks, she does not put the emphasis on details or analyses his exact wording, but rather takes them as representative of certain positions expressed by the circles surrounding him.

I will therefore compare their idea more freely by departing from Poincaré’s “science for science’s sake arguments and associate and compare them with Weil’s ideas. After giving a brief overview of Weil’s and Poincaré’s overall position, I will elaborate key points in both authors' perspectives. As I will show, they have similar views on the *telos* of science but disagree on the role and value of science as an institution in society. They also focus on different aspects. Poincaré is primarily concerned with the freedom of academic research, while Weil focuses on the relationship between science and education and the political significance of science.

3.1. Poincaré on Science for Science’s sake – two main arguments

As before mentioned, Poincaré’s “science for science’s sake” slogan was mainly a defence of science against the, in his view, dangerous attempts to interfere with and reduce the latter’s autonomy and freedom. Those attempts reached from anti-intellectualist attitudes to religious and secular ambitions to endow science with “external normative elements” such as moral values, ethical concerns, political ideas, and so forth. In his monographies *Science and method*, *The value of Science* and his late essay “Ethics and science”, he states that science should be done by scientists only, without interference from outside, and how this is better for everyone. His thoughts can be summarised in two main arguments, both aimed at leading to the same conclusion.

His first argument appeals to the teleological nature of science. Here, Poincaré holds that no (additional) moral or political influence on or within science is needed, since science in itself aspires towards the good, true, and beautiful, and therefore fosters moral progress intrinsically. This is so both on the collective and the individual level. Collectively, scientists do not engage in science for base motives such as money, vanity or industrial needs, but because of their love for the truth and beauty science reveals. People working in science dedicate themselves to the wonders of nature and the intellect which makes them increasingly detached from material needs and egocentric concerns. So, in a stoic sense, science indeed does his part in reducing suffering on earth by directing our attention to the abstract and eternal. With regards to individuals, scientists, because of their love for truth, become better people. Scientific truth and moral truth, so Poincaré, are “impossible to separate”. One cannot seek one without seeking the other. Therefore, and because one cannot know the outcome of an enquiry before it is conducted, we should, for instance, put no ethical constraints on experiments with non-human animals but leave it to the “consciousness” of the scientist to inflict the least harm for the greatest gain of knowledge possible. However, he admits that there may be exceptions (people working in science without the right ethos).

The second argument in favour of science’s autonomy rejects the criticism that science pursued for its own sake constitutes some kind of elitist, intellectualist leisure with arbitrary or capricious outcome. As such, it allegedly does not take care of society’s needs and problems and is not “useful” to ordinary people. This criticism is connected to the call that since science is necessarily guided by certain values, these values should be in accordance with what is “useful” to society rather than left to the whims of an intellectualist elite.

On the one hand, Poincaré argues here that leaving science to scientists does not mean to leave its fate to chance or caprice. True, scientists have and should have a certain freedom in chosen their methods, criteria etc. – but freedom is not the same as arbitrariness. Science does not need "external criteria" because it has its own, carving nature at its joints. Technological progress made possible by scientific discoveries proofs this. It is also true that contemporary science has become very abstract and detached from ordinary thought and life-world experience, but this is to the benefit of all members of society. Most people are rather simply-minded and do not "enjoy thinking". They are happier to be entrusted with executive activities (e.g., operate machines) which cleverer people have invented, as long as they also benefit from the material wealth promoted by industrialisation, medical progress and the like.

It is important to note that Poincaré never combined these two lines of reasoning himself. He is by no means cynical when he talks about the telos of science, the beauty of nature or intellectual joy. Neither does he, I think, intend to put forward epistocratic or other undemocratic views.[40] For one thing, he is, as I said above, not actively promoting philosophical view in that direction but rather defends what he sees as "free science". I believe it is fair to say that he was only moderately interested in and acquainted with political philosophy, moral philosophy or ethics and so strongly focused on science that he was probably not aware how his remarks might read on the other end of the science-society relationships.

3.2. Science's telos and its aspiration towards the Good

Let us now have a closer look on his individual remarks on science's *telos* and how they connect to Weil's ideas. In the introduction of *Science and Value*, Poincaré addresses the widely discussed controversy if science has intrinsic value (and thus is a goal in itself) or whether it should aspire to an external goal, e.g., reduce suffering in the world. With great enthusiasm he argues for the former, holding that it is not (primarily) because it is useful that we study nature, but because of its intrinsic harmony and beauty:

> The scientist does not study nature because it is useful; he studies it because he delights in it, and he delights in it because it is beautiful. If nature were not beautiful, it would not be worth knowing, and if nature were not worth knowing, life would not be worth living. Of course, I do not here speak of that beauty which strikes the senses, the beauty of qualities and of appearances;

[40] In his last speech (entitled "The moral alliance" at the inaugural session of the French League of Moral Education, June 1912, three weeks before his death) he expresses serious concerns about the falling apart of societal cohesion and solidarity among people from different social and educational background).

> not that I undervalue such beauty, far from it, but it has nothing to do with science; I mean that profounder beauty which comes from the harmonious order of the parts and which a pure intelligence can grasp. This it is which gives body, a structure so to speak, to the iridescent appearances which natter our senses, and without this support the beauty of these fugitive dreams would be only imperfect, because it would be vague and always fleeting. On the contrary, intellectual beauty is sufficient unto itself, and it is for its sake, more perhaps than for the future good of humanity, that the scientist devotes himself to long and difficult labors. (Poincaré, 1908/2003, 367)

In this last sentence, Poincaré partly admits to the accusation that scientists pursue science "perhaps even more" for its intellectual beauty that for the future good of humanity. However, this is not due to a lack of interest for other people or selfish pleasure-seeking but due on the insight that those two aims are not mutually exclusive. Before developing his full arguments about science's intrinsic property of promoting the good, he takes position on the demand that science should rather strive towards a "useful" goal, such as reducing the suffering in the world. Poincaré does not deny its relevance or importance to science, but argues, in a stoic fashion, that humans' well-being and ability to cope with suffering is best achieved by making ourselves more independent and detached from "material cares". Such freedom by detachment, which Poincaré calls the "annihilation of the world" is best achieved by directing away one's attention from "material issues" and towards the joy and beauty of truth and intellectual labour. He thinks that by doing so, one can then lead a good life (relatively) independent of one's economic or medical condition.

> The search for truth should be the goal of our activities; it is the sole end worthy of them. Doubtless we should first bend our efforts to assuage human suffering, but why ? Not to suffer is a negative ideal more surely attained by the annihilation of the world. If we wish more and more to free man from material cares, it is that he may be able to employ the liberty obtained in the study and contemplation of truth. (Poincaré, 1905/2014, 205)

In this sense, "science for its own sake", understood as a teleological enterprise with intrinsic value, ultimately also promotes the good. It thereby does its part in reducing suffering by directing our attention to the abstract and eternal. It is not entirely clear whether he believes that this intellectual joy and freedom will eventually exceed the borders of the scientific community and may reduce common people's suffering as well. Poincaré says very little about public education. In *Ethics and Science* he remarks:

> Taught by teachers who understand and love it, science can play a very useful and very important role in moral education. But it would be a mistake to give it an exclusive role […] There are people who have no understanding of science […]. What an illusion to believe that if science does not speak top their mind, it will be able to speak to their heart!" (Poincaré, 1963, 108)

Furthermore, science brings scientist not just closer to what is true, but also to the good because we must not dissociate, so Poincaré, the search for truth from the search for justice, peace and prosperity. The link between what is true and what is good becomes even clearer when he states that in fact, there are two truths one must bring together: scientific truth and moral truth. Although they are usually (meaning: in his own ranks, among scientists) conceived of as two entirely separate things, Poincaré confesses:

> When I speak here of truth, assuredly I refer first to scientific truth; but I also mean moral truth, of which what we call justice is only one aspect. It may seem that I am misusing words, that I combine thus under the same name two things having nothing in common; that scientific truth, which is demonstrated, can in no way be likened to moral truth, which is felt. And yet I can not separate them, and whosoever loves the one can not help loving the other. To find the one, as well as to find the other, it is necessary to free the soul completely from prejudice and from passion; it is necessary to attain absolute sincerity. These two sorts of truth when discovered give the same joy; each when perceived beams with the same splendor, so that we must see it or close our eyes. Lastly, both attract us and flee from us; they are never fixed: when we think to have reached them, we find that we have still to advance, and he who pursues them is condemned never to know repose. (Poincaré, 1905, 206)

For Poincaré, the scientist possesses, at least in theory, a certain *ethos*. They must love both scientific truth and moral truth, but at the same time understand that such truths will never be fully conquered. This requires from the seeker immense detachment, resignation and humility, and an attitude marked by determination. By devoting to such a quest, we practise self-forgetfulness. This makes us less egoistic and individualistic in our thinking. Although science and ethics (or morality) are "separate fields", epistemic and moral virtues, knowledge, and certain values are equally important for the scientist. In this spirit, he argues that there should not be, for instance, any ethical restrictions to experiments on animals ("any legal intervention would be inopportune and somewhat ridicule") since there is no authority able to "deliver a competent judgement in scientific matters. […] in this regard, we must rely on our [the scientist's] conscience" (Poincaré, 1963, 107). Note that Poincaré speaks here of the individual scientist and not of science as an institution or a community.

3.3. Science for the greater good of society

The second argument I introduced is more pragmatic in nature. It responds to a similar claim but emphasises more practical aspects of science and its "products". Unlike in the first case, Poincaré answers now to a concrete statement: That of Lev Tolstoi, who claims that science pursued for its own sake in an absurdly elitist and intellectualist enterprise with arbitrary or "capricious" outcomes. As such, it is claimed, it does not take care of society's needs and problems and is not "useful" to ordinary people – a fact that should be changed. Tolstoi argues that since science is necessarily guided by certain values, these values should be in accordance with what is "useful" to society rather than left to the whims of an intellectualist elite. As we will see, Poincaré does not deny that science is an elitist and intellectualist business. His response to Tolstoi refers, as we will see, to the last bit about the arbitrary and capricious criteria of "choosing facts". Poincare summarises the latter's position as follows:

> TOLSTOI somewhere explains why 'science for its own sake' is in his eyes an absurd conception. We can not know all facts, since their number is practically infinite. It is necessary to choose; then we may let this choice depend on the pure caprice of our curiosity; would it not be better to let ourselves be guided by utility, by our practical and above all by our moral needs; have we nothing better to do than to count the number of ladybugs on our planet ? (Poincaré, 2014, 362)

Looking back at Weil's remarks about the open universe with infinitely many possibilities and limitedness of the empiricists' "science game", one is inclined to think that Tolstoi's position as summarised by Poincaré may not have been entirely unappealing to her. However, although their writings show similarities in topics, terminology and in the kind of questions they address, this is more due to the shared cultural and intellectual background and ongoing debates they engaged in.[41] Furthermore, Weil had a genuine (although not exclusive) interest in science, while Tolstoi, a spiritualistic figure close to Catholic circles, addressed science mostly as rival institution to religion. Poincaré understands his position as such when he names it "matter of taste", and "not really of relevance to the question":

> It is clear the word utility has not for him the sense men of affairs give it, and following them most of our contemporaries. Little cares he for industrial applications, for the marvels of electricity or of automobilism, which he regards rather as obstacles to moral progress; utility for him is solely what can make man better. For my part, it need scarce be said, I could never be content with either the one or the other ideal; I want neither that plutocracy grasping and mean, nor that democracy goody and mediocre, occupied solely in turning the other cheek, where would dwell sages without curiosity, who, shunning excess, would not die of disease, but would surely die of ennui. But that is a matter of taste and is not what I wish to discuss. (Poincaré, 2014, 362)

In the second part of the quote Poincaré makes a few remarks on his own political "preferences", as he calls them, whereas in the first part he elaborates on the "attitude" he sees behind Tolstoi's and "most of our contemporaries'" position: technophobia with a religious undertone and little interest for "the miracles of science". To Tolstoi, "useful", so Poincaré, means something very

[41] Tolstoi defended a pragmatic and anti-intellectual attitude regarding science that was – in its general tone – not unpopular at the time, but quite far from Weil's ideas about science.

different from what it means to the businessman. With “useful” he does not describe what can be used to make money but what can make people (individually or collectively) better. For some reason, Tolstoi assumes that “the marvels of electricity or automobilism” produce rather the opposite effect.

This remark of Poincaré’s about some of his contemporaries’ peculiar understanding of “utility” is interesting and to keep in mind with regards to Weil’s ideas about science’s practical value and applicability that shall be addressed in the next sub-chapter. At this point, we also learn something about Poincaré’s understanding of “science for it’s own sake” that Weil so strongly associated with him. He continues by returning to the main issue he wants discuss: methods in empirical sciences.

> The question nevertheless remains and should fix our attention; if our choice can only be determined by caprice or by immediate utility, there can be no science for its own sake, and consequently no science. But is that true? That a choice must be made is incontestable; whatever be our activity, facts go quicker than we, and we can not catch them; while the scientist discovers one fact, there happen milliards of milliards in a cubic millimetre of his body. (Poincaré, 2014, 362-363)

As we have seen above, Tolstoi has claimed that there could or should not be “science for science’s sake” (“it is absurd”) because the universe (and the empirically observable phenomena in it) are infinite in number and we therefore need an “external” criterion of selection to limit our enquiry to the things we chose to observe. This criterion or “guide of the enquiry” is external in the sense that it is *a priori* to any observation, it may stem from purely intellectual interest (“the pure caprice of our curiosity”), “immediate utility” (problem-solving) or, as suggested Tolstoi, “moral needs”. Poincaré acknowledges the necessity of selection and of a criteria of choice. However, he does not think them to be necessarily “external” or “arbitrary” in the way Tolstoi suggests.

> To wish to comprise nature in science would be to want to put the whole into the part. But scientists believe there is a hierarchy of facts and that among them may be made a judicious choice. (Poincaré, 2014, 363)

This “hierarchy of facts” implies the idea of fundamentality[42] and the formulation of general concepts from specific instances by abstracting common properties. This is useful not only

[42] In the sense that some “facts” are – ontologically speaking – more fundamental, that is more simple and more general, than others. Science seeks to represent this natural hierarchy in specialist languages. Here, scientist have a certain freedom in choosing and applying concepts. The latter are, however, by no means arbitrary but striving towards the best explanation and prediction of reoccurrence. Poincaré’s idea of “simplicity” is strongly connected to his probabilistic thinking.

because it allows to organise a vast range of phenomena into relatively slim categories but also in terms of predication. The best proof of science's effectiveness and usefulness on the practical level are the technological progresses it makes possible.

> They are right, since otherwise there would be no science, yet science exists. One need only open the eyes to see that the conquests of industry which have enriched so many practical men would never have seen the light, if these practical men alone had existed and if they had not been preceded by unselfish devotees who died poor, who never thought of utility, and yet had a guide far other than caprice. As Mach says, these devotees have spared their successors the trouble of thinking. (Poincaré, 2014, 363)

At this point, Poincaré responds indirectly to the accusation that science has become an elitist business, highly intellectualist and disconnected from ordinary thought. Interestingly, he does not deny that this is so but rather point to the fact that there is not much harm in these circumstances. Most people, so Poincaré, are guided by instinct rather than reason. They "do not love to think", but are happy to profit indirectly from thinking progress made by others. Here, Poincaré point to the personal gain "ordinary thinkers" have from science as it is now, and from SfSS. In what follows, he then extends his argument to people in the collective sense. Simple-minded people, he says, although themselves being guided by instinct, indirectly profit from science because it made human evolution possible. Instinct guides them most effectively through the kind of lives they lead, but if it there were not those others who thought "beyond immediate utility" and personal enrichment, human evolution would not have carried us further than insects.

> Those who might have worked solely in view of an immediate application would have left nothing behind them, and, in face of a new need, all must have been begun over again. Now most men do not love to think, and this is perhaps fortunate when instinct guides them, for most often, when they pursue an aim which is immediate and ever the same, instinct guides them better than reason would guide a pure intelligence. But instinct is routine, and if thought did not fecundate it, it would no more progress in man than in the bee or ant. It is needful then to think for those who love not thinking, and, as they are numerous, it is needful that each of our thoughts be as often useful as possible, and this is why a law will be the more precious the more general it is. (Poincaré, 2014, 363)

So, it is important that those who "love to think" keep thinking, for themselves but also for the many who don't, but profit from their ideas. They profit from it directly, e.g., economically, and indirectly, *qua species*, as part of "humankind" and its evolution. Their "fear of science" as Poincaré calls it, has mostly to do with the fact that science promises progress, but not happiness. It opens a vista of a continuous advancement, a different – yet for most people incomprehensible – future which is not (necessarily) directed towards the fostering of their well-being.

> But if science is feared, it is above all because it can not give us happiness. Of course it can not. We may even ask whether the beast does not suffer less than man. But can we regret that earthly paradise where man brute-like was really immortal in knowing not that he must die? When we have tasted the apple, no suffering can make us forget its savor. We always come back to it. Could it be otherwise? As well ask if one who has seen and is blind will not long for the light. Man, then, can not be happy through science, but today he can much less be happy without it. (Poincaré, 2014, 363)

It is true that science does not promise or provide happiness yet changes our lives substantially. One might say, so Poincaré at the end of his essay, that we might not have any regrets if it were not so. Here he anticipates an argument that is often used against technical progress. It is true, possibly we would not miss any of science's great inventions, had they not taken place, and we would not be more or less happy than we are now. But we would be much less happy to renounce them, once we know about their existence and their practical benefits. So, to sum up this last point: Everyone, also those who "do not love to think" benefit from scientific progress, in so far as it entails technological progress and economic wealth none of us would want to miss. It is true that the latter do not take intellectually part in these developments and do not "understand" what lies at the bottom of the new machines and medical treatment they benefit from. But there is also no reason to complain or try to "go back".

3.4. Knowledge and progress

Weil's criticism partly targets this way of "doing science" per se – she thinks that epistemology should proceed methodology and not follow suit. She also does not see why we would need to examine parts of "physical reality" that are entirely "out of our reach".[43] Or, at least, why they should be considered "more fundamental" than the reality we engage with in our everyday life. What she finds, however, most problematic is the attitude contemporary scientist display with regards to science's role and function in society: On the one hand, they go along the lines of "science for science's sake", as proclaimed, for instance, by Poincaré. Scientific activity should by no means be influenced, corrupted, or constrained by "external" interest, be in political, economic, or intellectual in a broader sense. The latter rejects, e.g., criticism of the counter-intuitiveness of non-Euclidean Geometry by asserting that "if there cannot be "science for science's sake, there could be no science at all":

[43] This refers to Poincaré's remark that scientist seek "general facts" "in the two extremes, in the infinitely great and in the infinitely small." (Poincaré, 2014, 364)

> Les savants modernes, considérant, comme, semble-t-il, il leur convient de le faire, la connaissance comme le plus noble but qu'ils puissent se proposer, refusent de méditer en vue des applications industrielles, et proclament bien haut, avec Poincaré, que, s'il ne peut y avoir de Science pour la Science, il ne saurait y avoir de Science. (Weil, 1966, 13)

So, in Weil's understanding, scientists who claim that science is and ought to be a business on its own think of application questions as somewhat "beneath themselves". The same goes for "ethical questions". It is investigating purely theoretical questions they cherish as "the highest goal" – whether and how their theoretical discoveries can be applied to practical matters is for others to decide. Although not unimportant, applicability can be a bonus but never a constraint to their theories. As we have seen, this is only partly true for Poincaré. He definitely favours theoretical over practical knowledge (and indeed thinks that science should merely seek the former), but his rejection of the "needs of the industry" is much less pronounced that his dislike of the idea of "moral" or ethical constraints in science. On the other hand, they justify (some of) their scientific theories by pointing to the fact that they entail "practical progress" (e.g., that they give rise to new inventions that foster industrial and economic growth).

Weil has apparently read at least parts of Poincaré's philosophical works. However, her engagement with his arguments remains implicit in so far as she rarely cites directly from them. It is therefore hard to evaluate to what statements of Poincaré's she is exactly referring to and how well she knew his arguments.

Unlike Poincaré, Weil's main preoccupation is more with the influence of the industry on science, or, as she puts it "that science is reduced to a mere tool" and "put into the industry's service" (Weil, 1966, 12). As we have seen, she welcomes – at least in parts –the idea of a closer alliance between science and society. However, Weil thinks of this alliance mostly with regards to moral and political issues. Given the political landscape at the time,[44] it is not difficult to see why she hoped French intellectuals would concern themselves with those issues rather than keep inventing convenient languages ordinary people cannot understand. However, she also thought that some of science's inventions had harmful effects on society and especially on the lower social strata (e.g., in the context of industrialisation). As we will see, Weil, like

[44] Although issued victoriously, France was hit harder by the war than the other belligerent nations – in human losses, the systematic devastation of its richest regions, industrially and agriculturally, as well as strong social antagonisms and political dissatisfaction in all classes of society. The very late industrialisation of the country and the emergence of large factories shortly afterwards brought along inhuman living conditions for the kriegsversehrten workers and antisemitism was in the ascendent. (Jèze, 1921)

Poincaré, believed in science and its intrinsic value. However, she was very critical of its increasing specialisation and isolation from societal matters.

As we have seen, Poincaré holds that applications in the sense of technological development are an important by-product and a proof that it pays off to leave science to scientists. However, these practical achievements should not be confused with the real *telos* of science (love for wisdom and truth, the beauty of the structure of universe in our minds). While Weil puts great emphasise and reflects at length on the epistemological consequences of application-driven science, Poincaré's point – and interest – seems much more pragmatical and concrete: It is a good thing that technology benefits from scientific progress, but we should not put the cart before the horse. Technicians are no scientists.

Central to Weil's criticism of science being application-driven and having developed a "capitalist dynamic", is her understanding of 'progress', both in science and society. As we have seen, she thinks that progress in those two areas is closely connected:

> Pourquoi souhaiterions-nous pour la science un progrès sans obstacle ? Nous n'avons aucun bonheur à espérer du développement de la technique, tant qu'on ne sait pas empêcher les hommes d'employer la technique pour la domination de leurs semblables et non de la matière ; quant à nos connaissances, le progrès scientifique ne peut pas y ajouter, puisqu'il est reconnu aujourd'hui que les profanes ne peuvent rien comprendre à la science, et que les savants mêmes sont profanes hors de leur domaine spécial. (Weil, 1966,144)

Weil's remarks on progress, especially on scientific progress, relies on two aspects that cannot be separated: a political and an epistemological one. At the beginning of the quote just cited, she construes scientific progress mainly in a political sense: We have no happiness to hope for from the development of technology, as long as we cannot prevent men from using technology for the domination of their fellow citizens instead of becoming masters of nature. So, for Weil, scientific progress in a holistic sense does not solely depend on the theoretical discovery of new facts or the accumulation of true statements, but also on the way how we come to make use of them. That is not to say that new scientific knowledge necessarily has to entail action on the practical level, but in order to speak of 'progress' it should help us *do* something or *understand* something that goes beyond "knowing that p". This "something" should have value outside science, it the world. It should be of practical relevance to people and make their lives better (e.g., to help us understand and control natural phenomena).

In the second half of the quote, Weil comments on progress in the epistemological sense, that is on advancements in knowledge. We do not make, so Weil, progress by simply accumulating knowledge, especially not when this is achieved by the division of labour and specialisation. Ordinary people nowadays do not understand anything about science, and scientists are as ignorant as ordinary people in fields other than their own. Weil then goes on to elaborate on these considerations with regard to how they relate to individual mental processes. The insular, domain-specific knowledge contemporary scientists produce is the result of science transforming into a kind of "industrial knowledge production". She sees here an analogous development to the producing of goods in factories where work steps are divided among different responsibilities, and everyone continues to process a product of which they do not know exactly how it came about. So, Weil rejects such division of labour in the domain of science as a means in order to achieve progress. And she thinks that the kind of progress recently achieved by contemporary science is precisely of this character.

If we think back to her ideas about the unity of knowledge discussed in chapter 2.1, we might read this merely as another objection to the compartmentalisation of science as a whole. At this point, however, Weil refers here to knowledge as a product of the mind rather than to science as a political institution. Classical science is limited, so she holds, because the human minds is limited. So, the unity to which she is referring here has first and foremost to do with mental states. Even the most gifted among us, so Weil, have limited mental capacities in memorising facts, which is why *synthesis* is needed.

> La science classique est limitée quant à l'extension, parce que l'esprit humain est limité. Les hommes diffèrent entre eux ; mais même chez les plus doués l'esprit humain ne peut pas embrasser n'importe quelle quantité de faits clairement conçus ; pourtant une synthèse ne s'accomplit qu'entre des faits conçus par un même esprit ; il ne peut y avoir synthèse entre un fait pensé par moi et un fait pensé par mon voisin, et, si mon voisin et moi-même pensons chacun deux, il n'en résultera jamais quatre. Or toute théorie physique est une synthèse dont les éléments sont des faits conçus comme analogues les uns aux autres. Comme les faits s'accumulent à mesure que les générations de savants se succèdent, au lieu qu'il n'y a pas de progrès dans la capacité de l'esprit humain, la quantité des faits à embrasser en arrive à dépasser de très loin la portée d'un esprit ; le savant a dès lors dans l'esprit non plus les faits, mais les synthèses opérées par d'autres à partir des faits, synthèses dont il fait à son tour une synthèse sans les avoir révisées.

Here, we meet another Kantian concept in Weil's philosophy of mind: Synthesis as a power and activity of combining and uniting different representations given in intuition under one cognition. Strawson and Allais (2018) summarise the notion in the context of Kant's "transcendental self-consciousness" as follows:

> The key to the unity of consciousness, it seems, is to be sought in the fact that the connectedness of our perceptions is produced by the activity of the mind. The process of producing such connectedness or unity is called synthesis; and our consciousness of the identity of ourselves is fundamentally nothing but our consciousness of this power of synthesis, or combination, and of its exercise. I can count a given representation as mine solely because I have combined or synthesized it with others. Kant […] remarks: "The thought that the representations given in intuition one and all belong to me is ... equivalent to the thought that I unite them in one self-consciousness or can at least so unite them." Later he writes: "I exist as an intelligence which is conscious only of its power of combination." (Strawson and Allais, 2018, 90)

At this context, Weil seems to construe the cognitive process of synthesis as a necessary condition for someone to be able to say, "I know p" or "I have knowledge or p" (with emphasis on 'I' as the knowing subject). Synthesis, she continues, is accomplished only between facts conceived by one and the same mind; there can be no synthesis between, for example, a fact thought by me, and a fact thought by my neighbour. This is of course not to say that one has always to go through the whole process of acquiring representations empirically in order to make a synthesis, it can also be apprehended theoretically. But the process of combining and uniting them, that is to understand how they come together in our overall conceptions, must be comprehended by the power of one's own mind. It is not enough to adopt the synthesis completed by someone else and build on it.

This has severe consequences for Weil's epistemology. For one thing, she seems to reject the idea of testimony as a fundamental source of knowledge. We can learn 'facts' from other people, but we have to think them through and unite them under the right concepts by ourselves to call them "something we know". More generally, this means that she rejects the existence of a de-personalised (that is to say, non-individualistic) species of knowledge, as, for instance, proposed by advocates of 'social knowledge' (e.g., by Bird, 2010). Social knowledge, for Weil, supervenes on facts about what individuals know (their mental states). With an eye to scientific knowledge this would mean that for Weil, "I know that p" is a belief which is based on my own judgment that p is true, and not on the judgement that some else's judgement (statement) that p is true is true (as is typically the case when we rely on expert knowledge).

Weil's writings offer little that would allow us to determine her position on what qualifies as knowledge more clearly. We can, however, state as minimum requirements of her position that, first, thoughts or concepts as mental states supervene on the thinkers who have them, second, it is not sufficient to belief *that* something is true in order to call it knowledge, but one has to know *how* it is judged true. One way to achieve this, so Weil, especially with an eye to public education, is to transfer theoretical knowledge into practice (rather than the other way round).

> Le progrès de l'humanité ne consiste pas à transporter dans l'étude théorique les procédés de routine aveugle et d'expérience errante qui ont si longtemps dominé la production. C'est là pourtant tout ce que la science actuelle semble capable de faire, si l'on en juge d'après ce que disent les savants. Le progrès consisterait à transporter, autant qu'il est possible, dans la production elle-même, ce que l'humanité n'a d'abord trouvé que dans les spéculations purement théoriques, et complètement abstraites des applications ; à savoir la méthode. Descartes, qui aurait voulu fonder une université ouvrière où chaque ouvrier aurait acquis les notions théoriques nécessaires pour comprendre son propre métier, était plus proche de l'idée marxiste de « division dégradante du travail en travail intellectuel et travail manuel » que ceux qui, aujourd'hui, se réclament de Marx.

For Weil, real progress in contemporary science would mean to carry theoretical knowledge into practice and apply methodological considerations to practical processes. This emphasis on a top-down approach testifies, on the one hand, to her rationalist understanding of knowledge.

On the other, we meet the Marxist idea that the division of labour into intellectual and manual work has an alienating effect on workers becomes it separates them (here intellectually, but also in other forms) from the goods they produce. Working on machines in factories, they physically engage in processes they do not understand. Weil sees here a similarly one-sided relationship between scientists and their theories: They theoretically create systems and processes with which they personally never come into real contact. In this sense, Weil disagrees with Poincaré that the fact that scientific knowledge is being used for technological progress is a sign that science is "done the right way". First, because scientists, at least at Weil's time, were usually not the ones who applied their knowledge. It was rather left to technicians to "make something out of it" at some later point, and they were often oriented more towards personal gain than towards broader social interests. In this sense, scientific progress often caused damage rather than good on the practical level.

3.5. Science, education, and freedom

At this point, Weil's thoughts on the philosophy of science blend in with the practical philosophy she developed throughout her later writings.[45] Being a high-school teacher and

[45] Note that her ideas on science outlaid so far drew on her dissertation. Some of these points – especially the ones concerning science's connection with education and its role in society were taken up and connected to her political philosophy in later writings.

political activist in numerous labour movements, she became increasingly aware of the consequences that science's moving away from the classic humanist tradition had on education, both in the school context and in the context of society as a whole. In *Oppression and liberty* (1955), she connects her anthropological understanding of humans as creatures striving towards knowledge and self-understanding to her observations of oppression of working-class people. In her view, deliberation and freedom cannot merely be achieved intellectually. One cannot simply give into the joy of intellectual work or the admiring of the beauty of the laws of nature though science. The true starting point must be the recognition of our vulnerability and the "brutal forces" that nature exercises upon leaving creatures.

Weil does not believe, like Poincaré, that freedom through deliberation consists merely in shifting away one's attention from existential needs. As we have seen in her reflections on "work", she is aware that certain hardships, like illness and pain, but also "limitations" posed by one's biological disposition and "natural forces" determine what we can and cannot do. Turning her back on strongly dualist conceptions of the mind and body relation, she develops an alternative formula to Descartes famous *Cogito ergo sum argument* ("je pense, donc je suis"): "Je puis, donc je suis". For thinking, so she argues, is just a kind of ability to act (pouvoir), an expression of power or capacity.

> […] ma propre existence que je connais, je ne la ressens pas, je la fais. Exister, penser, connaître, ne sont que des aspects d'une seule réalité : pouvoir. je connais ce que je fais, et ce que je fais, c'est penser et c'est exister ; car du moment que je fais, je fais que j'existe. je suis une chose qui pense. (Sur la science, p.39)

While Descartes opposes the realm of thought and the product of reasoning as the "real" to the "illusions" produced by our senses, Weil takes human beings, at least partly, to be "things among other things", that is to have a strong "anchor" in the material world. She is not an anti-intellectualist like Tolstoi and his followers in the "bankruptcy of science" debate, but she is very suspicious about too far-reaching intellectualism as the other extreme. The idea that intellectual joy can save us from material misery is too simplistic in Weil's view. As long as we live, we will be – to some extent bound – to our body.

This becomes clearer in her treatment of the will or the "power" of thought: Even if all we wished for were to happen, still this would only be a "favour granted by fate", so to speak: for there is no logical connection between the will and the world, which would guarantee it; and the supposed physical connection itself is surely not something we could will. Our will (in the sense of our desires, intentions, beliefs, and thoughts) so she states, has no physical power by itself, it is – as everything else - subject to necessity. We know ourselves by our experience of interacting with the world, by affecting and being affected ("faire et subir"), and it is this very potential that defines what we are.

> Ce que je suis se définit par ce que je puis. (Weil, 1966, 40)

However, humans do have the power of freedom of thought. This won't make the world turn clockwise, in the sense that it won't change "the laws of nature". But it allows us to understand what is happening to us. Precisely because we cannot simply "free ourselves" from suffering and being subjected to natural forces in and outside our bodies, it is of major importance that we can understand and critically reflect upon our "wretchedness" and vulnerability in order to make sense of it and integrate it into our biography and world-view.

A central condition to individuals' freedom is therefore the faculty of self-determination which is "essential to our being" and something we can never renounce (Weil, 2013, 64). Human freedom is not simply the absence of cravings and needs, so Weil, but constitutes a sort of "heroic conception" of the self-determined agent:

> True liberty is not defined by a relationship between desire and its satisfaction, but by a relationship between thought and action; the absolutely free man would be he whose every action proceeds from a preliminary judgement concerning the end which he set himself and the sequence of means suitable for attaining this end. It matters little whether actions in themselves are easy or painful, or even whether they are crowned with success; pain and failure can make a man unhappy, but cannot humiliate him as long as it is he himself who disposes of his own capacity for action. (…) Living man can on no account cease to be hemmed in on all sides by an absolute inflexible necessity; but *since he is a thinking creature, he can choose between either blindly submitting to the spur with which necessity pricks him on from outside, or else adapting himself to the inner representation of it that he formed in his own mind; and it is in this that the contrast between servitude and liberty lies* (Weil, 2013, 81)

So, Weil's conception of free agency is not output-centred but focuses on the soundness of mental representation and behaviour. There are two cases in which Weil associated this idea with concrete living conditions: First, she takes this idea into the context of social and economic disparity in society. In her view, power-structures determining class societies are essentially knowledge bound. In science moving away from intellectual discourse and becoming more and more "unconnectable" to ordinary thought she sees – among other things – the rise of a new epistocratic elite, ready to take over from catholic priests.[46].

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[46] These remarks should be, of course, seen and evaluated in their historical context. As briefly describes above, French society at the time was still – and once again – torn between old catholic forces, on the one hand, and a

The second context where Weil discusses her ideas about deliberation is her observations and analyses of the living conditions of factory workers.[47] Wage-workers in the industrial age do not simply 'sell' their time for money, as they used to as craftsmen. In the factory, there is a "dead mechanism" which is independent of the workers and which incorporates them as living cogs. To the opposition created by money between buyers and sellers of labour power was added another opposition, created by the very means of production, between those who possess the machine and those whom the machine possesses. The complete subjection of the worker to the enterprise and to those who run it is based on the structure of the factory and not on the system of ownership:

> La séparation des forces spirituelles du procès de production d'avec le travail manuel, et leur transformation en forces d'oppression du capital sur le travail, s'accomplit pleinement... dans la grande industrie construite sur la base du machinisme. […] Si l'on néglige la manufacture, qui peut être regardée comme une simple transition, on peut dire que l'oppression des ouvriers salariés, d'abord fondée essentiellement sur les rapports de propriété et d'échange, au temps des ateliers, est devenue par le machinisme un simple aspect des rapports contenus dans la technique même de la production. À l'opposition créée par l'argent entre acheteurs et vendeurs de la force de travail s'est ajoutée une autre opposition, créée par le moyen même de la production, entre ceux qui disposent de la machine et ceux dont la machine dispose. (Weil, 1955, 16)

Similarly, so Weil, is Marx' "separation of the spiritual forces involved in production from manual labour", or, in another phrase, "the degrading division of labour into manual and intellectual work" the very basis of our culture, which is a culture of specialists. Science is a monopoly, not because of poorly organised public education, but because it is in its very nature that laymen have access only to the results, not to the methods, i.e. they can only believe and not assimilate.

> Ainsi la complète subordination de l'ouvrier à l'entreprise et à ceux qui la dirigent repose sur la structure de l'usine et non sur le régime de la propriété. De même « la séparation entre les forces spirituelles qui interviennent dans la production et le travail manuel », ou, selon une autre formule, « la dégradante division du travail en travail manuel et travail intellectuel » est la base même de notre culture, qui est une culture de spécialistes. La science est un monopole, non pas à cause d'une mauvaise organisation de l'instruction publique, mais par sa nature même ; les profanes n'ont accès qu'aux résultats, non aux méthodes, c'est-à-dire qu'ils ne peuvent que croire et non assimiler. (Weil, 1955, 44)

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nationalist and laicist efforts on the other. Write some more on "meritocratic ideas" and "state religion". Close proximity between French scientific and political élite at the time.

[47] Note that the "industrial revolution" in France, for a variety of reasons, began late and proceeded hesitantly. Until the early nineteenth century, the economy of the "grand nation" was mainly characterised by agriculture, small-scale trade, and craft enterprises that produced high-quality goods such as furniture, porcelain or clocks for the nobility and the bourgeoisie. In was from the mid-nineteenth century onwards that industrialisation was gaining momentum and the "classe ouvrière" was largely employed in big and highly technologized factories. (Jèze, 1921)

The structure of factory work makes workers politically and existentially incapable of action. This is so, on the one hand, because it renders impossible "transcendental self-consciousness" in the Kantian sense: Scientific elitism and 'specialist culture' make it impossible for workers to cognitively grasp scientific results and processes that determine their situation and integrate them into their existing knowledge of the world. Furthermore, besides this form of intellectual subjugation, workers experience an existential form of submission by experiencing themselves as a cog in the wheel. In her factory diary, Weil gives a phenomenological description from the perspective of the worker who learns to suppress any part of herself as a person and "wipes out her self-consciousness for 8 hours a day" in order to function as part of the machine.

> Il y a deux facteurs, dans cet esclavage : la vitesse et les ordres. La vitesse : pour « y arriver » il faut répéter mouvement après mouvement à une cadence qui, étant plus rapide que la pensée, interdit de laisser cours non seulement à la réflexion, mais même à la rêverie. Il faut, en se mettant devant sa machine, tuer son âme pour 8 heures par jour, sa pensée, ses sentiments, tout. Est-on irrité, triste ou dégoûté, il faut ravaler, refouler tout au fond de soi, irritation, tristesse ou dégoût : ils ralentiraient la cadence. Et la joie de même. Les ordres : depuis qu'on pointe en entrant jusqu'à ce qu'on pointe en sortant, on peut à chaque moment recevoir n'importe quel ordre. Et toujours il faut se taire et obéir. L'ordre peut être pénible ou dangereux à exécuter, ou même inexécutable ; ou bien deux chefs donner des ordres contradictoires ; ça ne fait rien : se taire et plier. Adresser la parole à un chef – même pour une chose indispensable – c'est toujours, même si c'est un brave type […] s'exposer à se faire rabrouer ; et quand ça arrive, il faut encore se taire. Quant à ses propres accès d'énervement et de mauvaise humeur, il faut les ravaler ; ils ne peuvent se traduire ni en paroles ni en gestes, car les gestes sont à chaque instant déterminés par le travail. Cette situation fait que la pensée se recroqueville, se rétracte, comme la chair se rétracte devant un bistouri. On ne peut pas être « conscient ». (Weil, 1951, 18)

Throughout her works, Weil refers at various points to historical ideas and attempts to establish adult education, which was completely absent in France at her time, e.g. by establishing a worker university (université ouvrière). Furthermore, in her letters to former colleagues at the university and at school, she exchanges ideas about initiatives in school that aim at a holistic concept of science education. As we have seen in Weil's essays on science and its connection to social structures, she sees the causes of social injustice as being rooted, at least partly, in the specialism of educational culture. However, she is aware that the development of contemporary science cannot be reversed. Nor does she think that it is realistic to hope for a further education of the workers that exceeds "the needs of the industry" ("Inutile de dire qu'en concevant ce programme, je ne me fais aucune illusion sur les possibilités de réalisation" (Weil, 1966, 79)). Therefore, she proposes building bridges through the reorganisation of teaching science in schools.

3.6. Weil's idea of a philosophical approach to teaching science in school

In her short essay *L'enseignement des mathématiques* (written between 1932 and 1945, published 1966) she presents a new didactic method for teaching philosophy, which she had developed during her employment as a teacher at a girls' grammar school. The aim of this "pedagogical experiment", she writes, is to develop a concept for the historical teaching of science, as it has been suggested by some of her contemporaries, e.g., the physicist Langevin. The idea is to teach sciences, and in this concrete case, mathematics, in light of its historical evolution. The goal is that students understand that mathematics is a product of human thought, not merely a set of dogmas.

> L'expérience pédagogique que je désire soumettre à mes camarades se rapporte à l'enseignement historique des sciences préconisé avec raison par Langevin et plusieurs autres. Étant professeur de philosophie, j'ai profité de ce que le programme comporte l'examen de « la méthode en mathématiques » pour consacrer une douzaine d'heures à l'histoire des mathématiques, présentée comme étant orientée vers une résolution de la contradiction fondamentale entre continu et discontinu (nombre). En voici une esquisse très sommaire. (Weil, 1966, 73-74)

Her approach is to take as a starting point a fundamental problem or question that runs through the history of the subject, so that theories in different eras can be analysed with regards to their contribution to a possible solution. As an example, she gives a brief outline of moments in the history of mathematics that can be seen as precedents of generalized number theory and infinitesimal calculus. Then she summarises her didactic ideas under three general criteria which should be satisfies by teaching science historically:

> À mon avis, l'enseignement de la science, pour constituer une culture, devrait comporter :
> 1º un enseignement pour une part au moins historique de chaque science, avec lecture de mémoires originaux, et, pour la physique, toutes les fois que ce sera possible, reproduction des expériences faites par les inventeurs ;
> 2º un enseignement de l'histoire des rapports entre la science et la technique ;
> 3º l'apprentissage et la pratique d'un métier productif, lié à un enseignement plus détaillé de l'histoire de ce métier dans son rapport avec la science et l'ensemble de la technique. (Weil, 1966, 75)

So, first, students should be given at least a partial historical overview of the evolution of the subject. For the empirical sciences, this should be accompanied, where possible, by a practical demonstration in the sense of a reproduction of the experiments or experiences which lead scientists to a certain discovery. Second, the teaching of science should address the history of the relationship between science and technology, which is at the same time a history of science's role in society. Finally, students should learn and practise, at least for a brief period, a productive trade. The latter should be linked to a more detailed teaching of the history of this trade in its relationship with science and technology as a whole. This approach, which she had tested with one of her classes, had been, so Weil, very successful and had led to a growing interest in mathematics even among those pupils who "at first glance did not show any particular talent in this area". (Weil, 1966, 74)

While these ideas may seem progressive but not overly innovative to today's readers, the trend for the most of the twentieth century in France was very much in the opposite direction. In order to apprehend Weil's suggestion of combining the theoretical teaching of science with practical aspects into context, it is helpful to briefly consider the French educational system at the time.[48]

To the educated middle classes striving towards higher education, demands for education to be brought closer to practice or work seemed absurd; and scientists demanded that schooling be adapted to the complexity and abstraction of the state of the art in the sciences, especially in mathematics. In short, it can be said that in the first half of the twentieth century there were two educational movements in France, which in the end met in "an unfortunate compromise" (Gispert and Schubring, 2007). The first movement, originating from the higher middle class striving for social advancement coupled with republican ideals of equality, demanded equal basic education for all. Until the very last years of their higher education, all French children should be taught the same curriculum. The second movement, driven by the scientific (and also largely political) elite, demanded excellence and highest theoretical standards, especially in science education. So, mathematics should be taught on the basis of the current state of science, e.g. according to the axiomatic method.

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[48] In her essay *L'enseignement des mathématiques au XXe siècle dans le contexte français* Hélène Gispert point to a major structural problem with regards to the teaching of mathematics in fin-de-siècle France. Until the 1930s, there were three different types of school curricula which referred to different social strata and followed different approaches to science. The first type, reserved for the intellectual and social elite destined to study at the *grandes écoles* such as the Ecole Polytechnique, aimed first and foremost at a classical and humanistic education. Here, mathematics and science were taught in a "very theoretical manner", since the focus was, also for nationalist reasons, still on literature and philosophy (the inter-war government wanted to distinguish themselves ideologically from the pragmatic German tradition). The second and third types of schools were designed to train higher and lower middle-class children for work in the industrial and commercial sector; the former as managers and the latter as technicians or workers. Here, mathematics and science were taught almost exclusively in a very practical and application-oriented way.
This system gave rise to long-lasting debates in France, since it caused discontent in all social classes. The social and scientific elite complained that their children were not being educated on the basis of the scientific and mathematical state of the arts. This would hamper their later careers in science. The aspiring middle class was unhappy because the class division of the school system and the separate curricula stood in the way of their children's climbing the social ladder.

Mathematical research in France at the time was dominated, or at least strongly inspired, by the Bourbaki school, which had published numerous volumes of the treatise *Elements of Mathematics*. The ambitious aim of this work was to completely reformulate mathematics, based in particular on the notion of structure. Several Bourbaki members (e.g. Dieudonné) strongly advocated politically – and, at least temporarily, successfully – for aligning the curriculum with their basic work. The main aim was to improve the general scientific level of the population through more abstract teaching from primary school onwards, and on the other hand to dust off the classical teaching of mathematics at school.

The compromise “with a bad ending” was met in the post-war period and can best be summarised by quoting one of the commissioners of the "maths modern" education reform in his speech to the public: “Should we teach outdated mathematics to children? No! Should less intelligent children be taught different mathematics? No!" Therefore, he concluded, everyone should be taught “scientific” mathematics, which is “formal and abstract” (quotes after Gispert and Schubring, 2007). Primary school pupils would, for instance, be introduced to mathematics starting with set theory. High school teaching, which previously strongly relied on geometry, arithmetic and trigonometry, should mainly focus on abstract algebra. (D’Enfer and Gispert, 2008)

The “equalisation from above” had a bad ending in a double sense: First, unsurprisingly, the introduction of the new curriculum was not crowned with success. Numerous complaints from teachers, parents, professors and even members of the reform commission about the “didactic disaster” and the practical unsuitability of “maths modernes” for most children led to its largely abolition as early as the 1980s (D’Enfer and Gispert, 2008; Gispert and Schubring, 2007; Gispert and Schubring, 2011). Second, Bourbaki’s treatise of structure, which constituted the model for the new teaching curricula in France, has been exposed as seriously flawed – “a from a mathematical point of view superfluous undertaking” – and was thereafter discarded by the scientific community (Corry, 1992).

Simone Weil, who died already in the early forties, would never witness these developments. Her outline of science didactics as a combination of philosophy of science, sociology of science and practical application can be seen as an alternative proposal to solve the curricular problems of the French school system in the 1930s and 1940s. Since social inequalities were paramount for Weil in educational issues, her proposals were based primarily on the idea of equalisation. However, this was not to be achieved by "upgrading" the education of the lower social strata, but rather by combining theoretical education with practical issues. Moreover, she did not believe that humanistic-literary education in grammar schools should be replaced by so-called scientific education. Instead, she defends a philosophical approach to science and technology that places scientific theories in their social context of origin and endows work (besides its practical) also with theoretical value.

Conclusion

In her critique and philosophy of science, Simone Weil discusses a range of developments in contemporary mathematics and physics in light of their theoretical and practical implications. These concerns, on the one hand, metaphysical and epistemological questions within the respective subjects and, on the other, broader philosophical questions concerning the relationship between knowledge and the mind, human freedom and social progress.

As we have seen, Weil places great emphasis on intelligibility. Very much in the spirit of French Third Republic philosophy, she critically questions the spreading positivist acceptance of the ultimate cognitive authority of science and rejects empiricist epistemologies of scientific experience in favour of a rationalist active role for the mind.
Generally, we meet this attitude in her critique of experimentalism and logical positivism in the natural sciences, as well as her criticism of the growing apart of science and philosophy. At the same time, she opposes to strongly 'intellectualist' approaches, especially with regards to anti-realism in mathematics (e.g., formalism). In concrete terms, she criticizes geometries departure from intuition, as present in non-Euclidean geometries and 'pure geometry', as well as conventionalist understandings of truth in mathematics as proposed, e.g., by Poincaré. Furthermore, she maintains the irreducibility of biology and sociology to physics and chemistry and argues that scientific models should account for essential aspects of 'human reality'.

When discussing the relationship between knowledge and the mind, freedom and social progress, Weil adopts a neo-Kantian perspective on knowledge and the self and advocates for an Enlightenment-inspired understanding of science that ties it more closely to public education and political concerns. Here, she comes out against specialist knowledge culture, elitist and epistocratic attitudes as she sees them in many scientists at her time and pronounces herself in favour of a rapprochement between the theoretical and the practical, in science and education, but also in everyday life contexts such as work.

Furthermore, she deals with the question of what actually constitutes science and scientific progress. Here she differentiates between the activity of striving for knowledge and science as an institution in society. Although she attributes an intrinsic value to the former, she holds that scientists in their role as professionals have social duties and responsibilities towards the rest of society. Science as a public institution obtains its practical value from its contributions to society. As we have seen, Weil, unlike Poincaré, understands 'contribution' and 'progress' not primarily in terms of advancements in technology and economical growth, but in advancements in understanding and morality by promoting self-determined agency and freedom through education. This feature of her thought becomes particularly salient when she connects her political views of science to phenomenological observations of the life-conditions of factory workers, as well as in her didactical concepts of teaching philosophy of science in school.

All in all, Weil's reflections are very diverse and multi-layered. In her intensive examination of individual theories in mathematics or physics, it becomes clear that Simone Weil, as a philosopher, had deep interest in and appreciation of scientific developments, as well as considerable knowledge of the history of science. At the same time, she has a very idiosyncratic perspective, characterised by a wide range of topics, certain ideals, ideas and attitudes towards science in general, as well as her political activism. This makes it difficult to place her within a specific context, both in terms of her views on science and herself as a philosopher.

As we have seen, her critique of some theories and approaches, such as Poincaré's conventionalism, do, at least partially, injustice to these accounts. Some of her observations and the conclusions she draws from them are over-generalising, not specific enough and neglect important aspects of the theories at stake. Also, her universalistic claims about large areas of science are not always well founded and context specific enough. At the same time, she pointedly draws attention to subtle dynamics and social structures that form the larger context in which science and education are embedded in, at the time but not only then. For instance, she is well aware that there are strong incentives, from inside and outside scientific communities, to strive for theoretical brilliance, productivity, and usefulness in terms of applications, rather than take on meta-perspectives and become politically involved. You do not make a career, become famous or win a Nobel Prize by stopping, critically reflecting, and drawing overall views of the rapidly growing body of theories and studies in science, or by discussing their meaning with regards to our world-views and values. Science has turned, similarly to the industrial sector, into a kind of 'mass production', and it would take a brilliantly gifted scientist, so she concludes in her essay on Quantum theory, a kind of holiness or heroism to stop voluntarily. And why should they be saints or heroes when neither, with rare exceptions, are people of other professions?

Also, Weil raises fundamental questions and problems, such as what role values are to play with regards to scientific research and how to deal with scientific findings in the political and economic context (this was to become, e.g., a big issue of discussion with the invention of the atomic bomb two years after Weil's death). Finally, Weil expressed some fundamental ideas that were only substantially developed decades later, such as in the field of social ontology.

In conclusion, Weil's philosophy of science and critique of science can best be understood as a critical attempt of a young philosopher to engage with contemporary scientific developments and the political situation of her time. Those who primarily look for a coherent conception of science and sophisticated, rigorous arguments on specialist issues will be disappointed by Weil's oeuvre. However, philosophers who can appreciate peculiar but interesting ideas, intuitively striking observations and outside-the-box thinking *despite* their formal deficiencies will find Weil an inspiring source. I hope to be able to contribute to it with my thesis.

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