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TEACHING HYPOTHESES WITH ÉMILIE DU CHÂTELET

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Abstract
The philosopher Émilie du Châtelet (1706-1749) was one of the most successful authors of her time in the fields of philosophy and science. Her texts were translated into several languages during her lifetime, which demonstrates the international appeal of her work. Many aspects contribute to her reputation as one of the most outstanding and famous philosophers of the 18th century. Among them is her emphasis on hypotheses as the basis of scientific research. The ideas she developed had an impact well into the 20th century, although her name had been forgotten. Her achievements can be discussed in a classroom setting by interpreting the chapter *On Hypotheses,* taken from her main work, the *Foundations of Physics*. The material has lost none of its significance and can, therefore, be a meaningful contribution to explaining the great ideas of the history of philosophy and addressing fundamental questions such as the discernment of what is true and false.

Keywords: Émilie du Châtelet, hypotheses, knowledge, methodology, philosophy of science

1. Du Châtelet, an Author with Impact on the History of Philosophy and Science

Du Châtelet was widely read and influential in her time, and her contributions to the fields of philosophy and science were significant. She corresponded with numerous celebrated authors who are regarded as prime examples of the Enlightenment, including Kant, Diderot, Condorcet, Voltaire, and Maupertuis, among others. (Du Châtelet 2018; Zinsser 2007)
Kant refers to her texts in his inaugural dissertation, and her influence is particularly evident in his so-called Copernican turn, an argument which is at the core of Du Châtelet's own arguments in favor of hypotheses. (Hagengruber 2022) Articles from her main opus, the *Foundations of Physics* (IP),[1] were widely copied in the *Encyclopedia* of Diderot and D'Alembert (Roe 2017),

[1] The *Institutions de physique*, originally published in 1740 and republished in 1742 under the title *Institutions physiques*, has been translated into English based on the 1740 edition (see Du Châtelet 2009). It is quoted here

among them also the chapter on hypotheses. The chapter was frequently copied in the contemporary literature of the 18th century, but its impact extended beyond that period. As Detlefsen (2019) remarked, Du Châtelet's ideas are echoed in Condorcet's theory of hypotheses. Le Ru (2019) and Paganini (2022) demonstrate the important role of Du Châtelet's ideas on hypotheses in the development of scientific reasoning throughout the 19th and 20th centuries.

The significance of her work can easily be observed in its publishing history (Kölving 2008). The *Institutions physiques*, an extensively enlarged second edition published in 1742, was immediately translated into Italian and German. In Germany, the book was listed among the must-reads until the end of the 18th century. Kant refers to her extensively in his *Thoughts on the True Estimation of Living Forces* (1749), and recent studies confirm that her influence on Kant remained throughout his lifetime (Winter 2019). Various members of the Berlin academy, such as its president Maupertuis (1698-1759, see also Hagengruber 2012: 25-40; 45-51), the famous mathematician Euler (Suisky 2019) and others have been connected to her (Du Châtelet 2018; Hagengruber and Hecht 2019; Reichenberger 2022). However, although she was one of the most impacting authors of the 18th century, her name subsequently disappeared from philosophy curricula, and her book is rarely mentioned today.

2. The Meaning of Hypotheses in Du Châtelet's Time

To understand the importance of Du Châtelet's analysis of hypotheses and to see how and why it forms a crucial contribution to the development of the history of science, the heated debate that characterized scholarly discussion must be examined. At the time, scientific innovations such as Newton's new concept of the universe emerged, as well as new disputes on methodology, definitions, and the theories of science. Since Newton could not explain the effect of gravitation within the accepted mechanist worldview – which analyzed cause and effect in terms of pressure and impact – his concept of independently moving planets, interacting according to their size and mass, proved difficult to comprehend. While the Newtonian scholars claimed the veracity of the Newtonian concept of gravity as proved by mathematical laws and observation, the mechanistic vortex model presented by Descartes was eagerly defended on the continent. The public dispute over hypotheses started when Newton, in the second edition of his *Principia Mathematica*, added the phrase "hypotheses non fingo", which was seen as a rejection of the speculations on the primary cause of gravitation. (Newton 1687/1999: 943) Newton and the Newtonians claimed to have observed and calculated gravitation, which was sufficient proof of its existence.

With his remark against speculative hypotheses, the Newtonian scholars found a legitimate reason to turn against the philosophy of the continentals, above all against the Cartesians. Descartes had not been able to derive this theory from observation. He based it primarily on principles of knowledge, on conclusions by which he attempted to show the beginning and course of movement in the universe. In 1733, Voltaire, mocking nationalist quarrels, wrote in his *Letters on the English* XIV: "A Frenchman who arrives in London will

according to this English translation, with chapter and paragraph references provided to enable readers to compare the text across different editions, as well as with the original French and the Dutch translation (2023).

find philosophy, like everything else, very much changed there. He left the world a plenum and now finds it a vacuum. In Paris, the universe is viewed as being composed of vortices of subtle matter, but nothing like it is seen in London". (Voltaire 1733/1894) Voltaire ridiculed these disputes because planetary motion obviously could not depend on the opinion of the French or the English. Later, Du Châtelet would take up exactly this problem. According to her, the divide in philosophy had to be overcome. National ideas could not be important where science was concerned. Du Châtelet, therefore, cautions her readers before dealing with how the problem of this epistemic divide should be solved:

> The love of your country must not prevail, and it is surely very unfortunate that the opinions of Newton and of Descartes have become a sort of national affair. About a book of physics, one must ask if it is good, not if the author is English, German, or French. (Du Châtelet 2009: 120)

Du Châtelet's chapter on hypotheses, packed with theories from physics and mathematics, both disciplines in which Du Châtelet was an expert, delivers the resources for overcoming the methodological problem of her time.

3. Hypotheses at Stake: The Historical Discussion

At least four crucially different ideas are juxtaposed in the problem at stake. On the one hand, the mechanistic worldview contradicts the description of planetary motion that depends on gravitation instead of impact, as introduced by Newton. Secondly, there was a problem with Newton's planetary concept. He had to bring in God, not only as the originator of the universe and all its movement, but also as the impetus to keep this planetary machine running. Although Newton claimed that the movement of the planets obeyed mathematical laws, he assumed the loss of speed to be due to friction, and it was God's entertainment when the machine was running slow. While Newton thought he could do without speculation, relying only on observation, experiment and mathematics, the rationalists thought that the first cause, the origin, could be reached by consistent reasoning and a chain of arguments that allowed the construction of an irrefutable world building based on these conclusions.

Du Châtelet's methodological procedure for judging competing scientific insights contributed crucially to framing the differences, branded today as the empiristic worldview. which relies on the observation of phenomena and their mathematical presentation, as opposed to the conflicting rationalist approach, in which principles must be followed to explain phenomena in the world. This, as well as the proposal to overcome this conflict became the main emphasis of Du Châtelet's book. She expresses her aim to overcome the divide in her introduction. (Du Châtelet 2009: 119)

A new philosophy of science and a new methodological framework were needed to overcome these established but outdated and conflicting insights. Those who study Du Châtelet's work can see how systematically this criticism is constructed and how carefully the architecture of a new philosophy of science is presented. The first three chapters play a crucial role in understanding the fourth chapter. In the first three chapters, the above-mentioned problems are discussed in more detail and constitute the basic insights that are brought together in chapter four. While these preceding chapters cannot be presented here in length, their relevant ideas can.

The first chapter, dedicated to the principles of knowledge, limits the extensive validity of these principles. (Carus 2024) Accordingly, principles of knowledge, such as the principle of contradiction, though confirmed in their universal validity, are critically reviewed insofar as they cannot secure the finding of true causes, because these are often too far removed for us, and conclusions become weak when expanded into realms that cannot be controlled by observation. The second chapter deals with the necessity of God as the cause of all causes, the peak of all reasoning, that can never be found or confirmed but only assumed by *sufficient reasoning*. (Lascano 2011; Carus 2025) Therefore, God cannot be a relevant element in the construction of science. The third chapter is written as a critique of the philosophy of John Locke. According to Du Châtelet, the philosophy and epistemology of John Locke is the basis for Newton's methodology. (IP 5.73) However, John Locke's muddled ontology, as she calls it ("entirely confused" IP 3.51; Hagengruber 2012: 8-13), is criticized, as it is not capable of determining how things in the world are connected to each other; it connects things according to how Locke sees them, instead of ordering them according to their essences and attributes. The philosophy of "sight and smell" is not adequate for the establishment of scientific knowledge. Even the frequency of an occurrence does not confirm the necessary connection between occurrences, nor does it allow one to recognize the essence of a thing. The knowledge drawn from observation and from personal principles of understanding, therefore, needs to be reorganized to suffice the claim of sufficient reason to find the true causes.

What we observe in Du Châtelet is an early critical examination of the methodological foundations of the different scientific approaches; her task is to overcome this "divide" in philosophy. Therefore, she needs to clarify the foundations of scientific knowledge, a kind of knowledge that is beyond personal and immediate experience. Each chapter in the book is organized in a similar way and this also holds for chapter four. At the beginning of each chapter, the positions of the various and contradicting parties are presented and their claims with their strengths and weaknesses are examined. In the middle part of the chapter, her analysis and its results for the problem are presented, whereas the third part is a reconstruction of the problem, presented according to her own analysis. Accordingly, Du Châtelet's chapter *On Hypotheses* firstly re-evaluates the main arguments from the Cartesian and Newtonian scholarship. The paragraphs 58-62 demonstrate her alternative interpretation of the problem, here presented as a "Copernican turn" and exemplified with the divergences that frame the divide between the Ptolemaic and Copernican cosmology. The final part of the chapter reconstructs how the reasoning must be organized to deliver what has been promised, a sure way to gain scientific knowledge by means of hypothetic reasoning.

4. Overcoming the Divide in Philosophy

In the tradition of Aristotle, all science is based on the investigation of causes, as Du Châtelet also laid out in the earlier parts of her book. Here the problem arises for all scholarly investigations involved. Even though she leaves open the possibility that some causes may be derived from first principles, causes are too far removed from the experiments that can be conducted. (IP 4.53) All those who reject this insight and who deny that this is the path to good science can only be wrong: there is no alternative but to settle for probabilities in the sciences and in physics, that is, in the study of nature.

Paragraph 54 deliberates about the beginning of any scientific investigation, which is, as she explains, a problem in itself. As all things are connected, there is no specific "point of nowhere" from which truth might be revealed.

Descartes built his system of knowledge on hypotheses but failed and fell into "fables and reveries". (IP 4.59) Descartes' rules of methods demand that a path once chosen must be followed, and the chosen principles must be applied and kept. Those who change the method get lost in erring and will never find their way out of the thicket. Du Châtelet quotes Descartes to refute this theory. Though there is a beginning in all research, there is no infallible way to truth. "There are unknown truths just as there are unknown countries" (IP 4.54). On the contrary, instead of recommending following the one path, Du Châtelet states that the search for truth is fraught with error. Therefore, it must be admitted that the knowledge gained through errors is essential, as erring enables the researcher to find a path to truth, similar to a path through "unknown countries to which one can only find the good route after having tried all the others". (IP 4.54) There is no perfect path, and Du Châtelet adds that this is true for every path. The perfect path cannot be found by strictly following principles. Neither can it be found by relying on observations and experiments. Descartes failed because he stretched the range of principles too far, and because he failed to test the principles with observations. Newton fell "into the opposite excess" (IP 4.55), as he denied the value of hypotheses and claimed that truth could be derived from observation and experiments. The position of the empiricist is rejected because there can be no completeness of observation: "he alone, who was able to assign and demonstrate the causes of all that we see, would be entitled to banish hypotheses from physics." (IP 4.55) A single observation or a set of observations is not sufficient to claim that the truth has been ascertained, as it can never provide a complete overview. Moreover, as Du Châtelet proved in chapter three, even iterative observation cannot secure knowledge, and the frequency of an occurrence does not confirm the necessary connection between occurrences. For no one can include all empirically possible constellations and cases in his or her investigations or is able to unveil the sheer sum of the essential connections between them. Consequently, those who rely on observation and experiments must also realize that they are moving in the realm of probabilities and not in the realm of facts. In his paper on hypotheses, Paganini points out how Du Châtelet delivered a first critical presentation of the weaknesses of the "theory of induction". Du Châtelet's emphasis on hypotheses was a response to the impossibility of inferring a universal law from experience data, and therefore to the most 'aristocratic' form of the issue of induction. (Paganini 2022: 47; Wells 2024) Du Châtelet concludes in this introductory first part of her investigation that "philosophers frame hypotheses to explain the phenomena, the cause of which cannot be discovered either by experiment or by demonstration". (IP 4.56)

5. The Copernican Turn: How Hypotheses Act as Causes

The Copernican Revolution has been a fixed term in the history of science for about two hundred years. Understanding this term and its role in theoretical discussions begins with the question of how the long-established Ptolemaic system – asserting that the sun revolved around the Earth and forming the foundation of a geocentric worldview – was eventually replaced by

Copernicus's proposal that the Earth, in fact, revolved around the sun. Du Châtelet's interpretation of the Copernican Revolution marks a pivotal moment in the history of the philosophy of science and became central to her methodological reflections on scientific knowledge in her chapter on hypotheses. The observable phenomenon and the principles used to analyze it appeared to be the same, yet the resulting hypothesis was opposite to its predecessor.

Du Châtelet's writing reveals that she was the one who emphasized the significance of explaining this shift in perspective within the history of science, recognizing that it was not simply a case of a "more evident" explanation replacing a less evident one. Du Châtelet's elaboration on the Copernican Revolution forms the core of her methodology and finally allowed her to introduce a new perspective on how science evolves. She replaces the search for truth by the search for the most probable hypothesis and substitutes scientific knowledge with sufficient reasoning that must be validated within a hypothetical framework of demonstrations and experiments.

Copernicus and Ptolemy, she holds, both started from the same observation, an observation that was as real then as it is today. It seems as if the sun revolves around the earth. However, and this proves that observation is not the crucial element of scientific truths, the two handled this everyday observation differently, giving it a different interpretation and meaning. Copernicus "simply did the opposite". (IP 4.57) The central argument underpinning her thesis is that observation alone is insufficient for scientific inquiry. Copernicus' explanation of the motions of the planets was grounded – as Du Châtelet explicitly confirms – on the same observation; he referred to the same principles to construe his theory, but he nevertheless astonished the scientific world with a different result, an opposing hypothesis. The example illustrates that the crucial conclusion based on the principles and observation is a hypothetical one and, therefore, not a necessary result.

The argument presented is not based on the claim that Copernicus had more data or that his result was more reasonable or that he had started from a different and more excellent starting point. The central thesis is that even on the basis of comparable data, the hypotheses drawn upon may turn out differently. The quite radical "he simply did the opposite" emphasizes that there is no reason or argument that privileged the Copernican hypothesis, though in the end, it turned out that the Copernican hypothesis proved to be more compatible with the phenomena in important respects. That is, the crucial outcome is an outcome that is deduced from the hypothesis, which had proved itself consequently to be more stable, more consistent with other data and observations to an extent that it is seen as "truthlike" (orig. *vraisemblable; vraisemblance*). (Du Châtelet 1742: 0.6-8; IP 4.55) The significance of the two different hypotheses is reflected in their effect and application to different fields of knowledge. While Ptolemy's hypothesis ran into insurmountable difficulties when the consequences were considered, it was shown that Copernicus' hypothesis proved to be stable precisely in terms of its application to other fields and the consequences that followed from it.

The freedom of a hypothesis takes precedence over strict methodology, thereby allowing science to continually evolve and renew itself. Du Châtelet carefully examines how a well-established theory – built upon extensive reasoning and numerous assumptions – can be challenged or replaced by a new one, especially given the persistence of established theories and their entrenchment in assumptions that continue to seek confirmation, often in opposition to newer ideas: "For when a hypothesis is once posed, experiments are often done to ascertain *if it is a good one,* experiments which would *never have been thought of* without it". (IP 4.58, emphasis REH)

The Copernican hypothesis was not "more reasonable", but – as she presents it – a provocative idea that could, bit by bit, extend into a wider realm of validation. At the same time, it is important to keep both theories at the methodological level of the hypothesis. It is emphasized that Copernicus' hypothesis does not constitute a definitive truth but rather serves as a framework that facilitates further scientific inquiry. This also changes the methodological status of the causes and the search for causes. Although a hypothesis may serve the purpose of standing for a cause, it is always a hypothetical one and cannot claim the truth by itself. The only thing that can be searched for is a truthlike explanation. "If Copernicus had waited for the true theory", astronomy would still be waiting for the true theory of the planets to be found, and "there would be no astronomy now". (IP 4.57) The validation process follows hypothetical reasoning, and the hypothesis proposed by Copernicus showed "so much an agreement with the phenomenon that its certitude is at present not far from demonstration". (IP 4.57)

> If it is found that these experiments confirm it, and that it not only explains the phenomenon that one had proposed to explain with it, but also that all the consequences drawn from it agree with the observations, its probability grows to such a point that we cannot refuse our assent to it. (IP 4.58)

The hypothesis is presented to be the central element of scientific theory; its closeness to the truth develops the more its consequences are confirmed by observations, experiments and all kinds of knowledge connected with it.

Using the example of the rings of Saturn, she presents her new theory that science is expanding our knowledge by means of hypotheses. The hypothesis of the rings of Saturn demonstrates that scientific hypotheses can become truthlike knowledge that did not exist before a hypothesis was made. What is known is not bound by what is seen, or only partially seen. This is demonstrated by the appearance of the "rings of Saturn", which are actually not rings at all.

> "For M. Huygens, who discovered it first, did not observe what astronomers now describe; but he observed several phases of it, which sometimes resembled nothing less than a ring." […] Comparing the successive changes of these phases and all the observations that he had made of it, he sought a hypothesis that fit them and explained these different appearances. That of a ring succeeds very well; it not only explains the appearances but also predicts the phases of this ring very accurately. (IP 4.58)

The ring cannot be seen as such: it results from different observations, dots of light interpreted and hypothesized by the astronomer Christiaan Huygens (1729-1795) that Saturn is surrounded by a ring that reflects light, separated from the body of the planet, and inclined to be ecliptic. The correspondence between this hypothesis and further observation converted Huygen's supposition into a certainty and "no one doubts that this ring is real and the conjecture of the ring of Saturn is justified". (IP 4.58)

6. Erring and The Rules to Confirm Truthlike Hypotheses

Le Ru pointed out that the inventive character of Du Châtelet's philosophy not only implies the theory of hypothetic reasoning but also the right, "even the obligation to err in science". (Le Ru 2019: 50) The positive concept of erring, together with the art of conjecture proves the history of science as a result of rectified hypotheses. As causes are not known in most cases, there is no perfect starting point for scientific understanding. Everything is connected to everything else and thus it is impossible to view the complete picture. Errors play a constructive role in a methodology based on various rules of deduction and refutation. This process of conjecturing about true causes stabilizes knowledge and allows new areas of scientific investigation to be opened up.

At various points in her work, Du Châtelet shows that she does not consider the true causes to be recognizable. This does not lead her to skepticism, according to which nothing can be known with certainty. Neither does it make her an idealist who would relativize the reality of the outside world as a mental phenomenon. (Fatema 2024) At a later point in her *Institutions*, she makes it clear that the real world is not accessible, and that perception is dependent on (scientific) understanding. However, the chapter on hypotheses makes it clear that the world functions as a metaphysical adjustment for our conjectures and hypotheses. Truth cannot be found, what is real cannot be proved or substantiated, but it functions as a limitation factor to the consistency of hypotheses. This metaphysical reality, though indiscoverable, is the true cause for the infinite process of hypothesizing about it. It is also the cause for judging a hypothesis as being truthlike, when no more errors and contradictions can be found in the conclusions that are drawn from it. With that, the second part is concluded, and Du Châtelet presents her methodological procedure – one that may serve both as instructional guidance and as a practical framework for classroom application (see paragraph 7).

To form a hypothesis, Du Châtelet developed various rules. Eleven have been extracted from them by Paganini (2022: 30-39). To ensure the success of the procedure right from the beginning, the greatest amount of available knowledge about a phenomenon serves as the best starting point for forming a good hypothesis. Otherwise, the risk is high that from the outset the hypothesis will prove unsuitable in the face of the slightest objection. The rules serve to subject the hypothesis to the closest examination to prove its stability, its probability and, hence, its closeness to the truth. A closeness that, as has been shown, depends on the process of confirming or denying the consequences of the truth of the hypothesis, thus proving the strength of the probability of a hypothesis, or its implicit faults. Starting from the insight that "Hypotheses are nothing more than probable propositions, with a greater or lesser degree of certainty" (IPms 2022, 4.B21, transl. REH), the task is to reflect on "why one is preferred to another." The search for truth becomes part of an "art of invention" and succeeds in testing these new ideas and hereby expanding science. (IPms 2022: 4.B20-26)

Reasoning about which "supposition" might give the most promising information on the phenomenon is the goal, as "one must have reasons for preferring the supposition on which it is founded to all other suppositions; otherwise, one spews forth chimeras, and precarious principles that have no foundation". (IP 4.68) The *Empiricism rule* holds that all relevant facts that are within our reach, the circumstances attendant upon a phenomenon to be explained, are collected. (Paganini 2022: 32; IP 4.61) The *Confirmation rule* calls for the deduction of all the consequences of a hypothesis and its comparison to experience. (Ibid.: 33; IP 4.66) The *Circumstantial rule* considers all circumstances surrounding a phenomenon. (Ibid.: 34; IP 4.61). The *Falsification rule* (IP 4.64) confirms that a hypothesis cannot be confirmed by any number of positive experimental outcomes, but one single counterexample can falsify a hypothesis. According to the *Probability and revision rule,* a hypothesis is considered valid until it is proven false, and as just one contrary experience can reveal its falsehood, the degree of truth can never extend beyond likelihood and probability. (Paganini 2022: 34; IP 4.67) The *Rule concerning abuse* refers to the mistake the Cartesians made by claiming their hypotheses to be true (Paganini 2022: 35; IP 4.63). Paganini further presents the *Precaution rule*, that states that a hypothesis should not be considered a truth, (Paganini 2022: 36; IP 4.60/62) and in the *Heuristic rule* he summarizes Du Châtelet's insight that hypotheses help to find new explanations and to provide new predictions, which are at the core of the progress of science. (Paganini 2022: 36; IP 4.57-58) The *Rule of parts* holds that a hypothesis can be true in one of its parts and false in another. (Paganini 2022: 37; IP 4.54) The *Rule against assumptions ad hoc* prevents that a hypothesis arises in spite of contrary factual evidence. (Paganini 2022: 38; IP 4.69) All these rules are supplemented by the *Principle of sufficient reason*, according to Du Châtelet the most important rule. This means that no hypothesis may be in contradiction with the principle of sufficient reason, nor with "any principles that are the foundations of our knowledge". (IP 4.61) This forms a "general cross-check of the whole methodology", to secure that a strong hypothesis is provided and to avoid the pitfalls in the provision of such a hypothesis, according to Paganini (2022: 39). In view of the fact that Du Châtelet's hypotheses were adapted and further developed over a period of centuries, this text about the rules for judging good hypotheses can be seen as the most successful and influential text from Du Châtelet's major work.

7. In the Classroom

In an era marked by fake news and ongoing debates about the credibility of scientific claims, it is essential to teach how science works and what it can truly offer. The need to justify explanations and conclusions is a topic as current as ever.

While teaching Du Châtelet, a compelling parallel emerges between the educational *content* and the learning *process*: while her writings on hypotheses explore the construction of scientific knowledge, learners are simultaneously engaged in constructing an understanding of her philosophical ideas. In their revision of Bloom's taxonomy – a widely used framework for categorizing educational goals – Anderson & Kratwohl (2001) describe the learning process as follows:

> In instructional settings, learners are assumed to construct their own meaning based on their prior knowledge, their current cognitive and metacognitive activity, and the opportunities and constraints they are afforded in the setting, including the information that is available to them. (Ibid.: 38)

When engaging with Du Châtelet's work, learners are assumed to construct their own meaning on the topic at hand, thereby gaining new insights into the processes through which scientific

knowledge is attained. It may be valuable to highlight this parallel for learners – that they are gaining knowledge about gaining knowledge – at an appropriate moment during classroom discussions.
Anderson and Kratwohl continue to describe four general types of knowledge: factual knowledge, conceptual knowledge, procedural knowledge, and metacognitive knowledge. The table below is an adaptation of the model by Anderson and Krathwohl (2001: 46), which contains a short description of each type of knowledge, as well as an example of what learners might be expected to know about Du Châtelet after her work is covered in class.

Knowledge type	**Description**	**Examples relating to Du Châtelet's *On Hypotheses***
Factual knowledge	The basic elements students must know to be acquainted with a discipline or solve problems in it.	Knowing the difference between the Ptolemaic and the Copernican cosmology.
Conceptual knowledge	The interrelationships among the basic elements within a larger structure that enable them to function together.	Knowing how hypotheses, empirical evidence, and truth relate to one another in scientific inquiry.
Procedural knowledge	How to do something, methods of inquiry, and criteria for using skills, algorithms, techniques, and methods.	Knowing how to apply the methodology of hypothesis formulation that Du Châtelet advocates, to ensure the validity of scientific reasoning.
Metacognitive knowledge	Knowledge of cognition in general as well as awareness and knowledge of one's own cognition.	Knowing how Du Châtelet's insights into the limitations of human knowledge foster an attitude of intellectual humility.

Tab 1: Knowledge Types and Examples

In the remainder of this paragraph, we will elaborate on each of these knowledge types and offer suggestions for the implementation of learning activities that will contribute to obtaining knowledge of this specific kind. When focusing on metacognitive knowledge, we will also explore if the process of knowledge construction that the learners have experienced while learning about Du Châtelet, could itself contribute to a deeper understanding of her work on hypothetical reasoning and knowledge construction.

7.1 Factual Knowledge

Factual knowledge consists of isolated terms and facts that serve as an essential foundation for a more profound understanding of the material. (Anderson & Kratwohl 2001: 42) Applied to our object of study, an example of factual knowledge would be to have a general understanding of what the Ptolemaic and Copernican cosmologies entail, before addressing how both systems appear in Du Châtelet's work and their relation to hypothetical reasoning. The University of Nebraska-Lincoln[2] provides excellent online simulations of the Ptolemaic and Copernican models, which can be effectively used in a classroom setting. It is advisable to ensure that learners possess the necessary factual knowledge before engaging in learning activities that emphasize other types of knowledge. This ensures that learners construct meanings that are built on a solid foundation – or in the words of Anderson & Kratwohl, that "coincide with authentic aspects of reality". (Anderson & Kratwohl 2001: 38)

It is worth noting here that the concept of knowledge construction also takes up a prominent place in James Banks' seminal work *Cultural Diversity and Education*, where it is characterized as one of the key "dimensions of multicultural education." Banks' five dimensions have become a widely adopted model to promote equal opportunity in education. Banks stresses the importance of addressing how cultural assumptions influence scientific practices:

> It is important for teachers as well as students to understand how knowledge is constructed within all disciplines, including mathematics and science. […] However, the disciplines are often taught to students as a body of truth not to be questioned or critically analyzed. Students need to understand, even in the sciences, how cultural assumptions, perspectives, and frames of reference influence the questions that researchers ask and the conclusions, generalizations, and principles they formulate. (Banks 2016: 10)

Voltaire's critique of the differing scientific frameworks in Paris and London (see paragraph 2) serves as a compelling example to illustrate Banks' point. This introduces yet another dimension to the relationship between knowledge construction and the classroom: first, knowledge is constructed when learners engage with Du Châtelet's legacy; second, her work itself offers a theoretical framework for the construction of knowledge; and third, her historical context exemplifies the broader influence of culture on knowledge construction.

7.2 Conceptual Knowledge

As described in paragraph 3, each chapter of the *Foundations of Physics* adheres to a recognizable structure. Du Châtelet presents two contradicting views, followed by her own analysis and a reconstruction of the issue. This rigorous juridical method is described in Hagengruber (2024: 75-76): "Like a judge, who did not witness the actual events, Du Châtelet deliberates which arguments come closest to a truthlike presentation of the matter at hand."

Du Châtelet's juridical method aligns seamlessly with the debate format – a classroom activity that encourages the creative exploration of pro and contra arguments. Especially when debaters are assigned a position on a topic rather than choosing one, they collaboratively develop a map of arguments around a given topic, while weighing points on one side against those on the opposing side. (Velema 2022: 67) After the debate, learners can articulate their own position in a classroom discussion. By applying the juridical method in a classroom debate, learners, like

[2] See the Solar System Models Module of the Nebraska Astronomy Applet Project. For a Ptolemaic System Simulator, visit: https://astro.unl.edu/naap/ssm/animations/ptolemaic.html. For the Copernican model, visit: https://astro.unl.edu/naap/ssm/animations/configurationsSimulator.html. (Download 10/01/2025)

Du Châtelet, will be better prepared to form their own well-informed opinions on a given topic. At the same time, they will have acquired in-depth conceptual knowledge of the key notions in Du Châtelet work, by applying them in an active, student-led learning activity. (Velema 2022: 65)

Newman (2022) outlines a diverse range of debate formats suitable for the philosophy classroom, adaptable to different durations and group sizes. In most cases, the debate format revolves around a *debate motion*: a clear statement that serves as the focal point for exploring opposing points of view. We propose the following debate motions as examples addressing epistemological topics:

1. This house believes that speculation is a necessary step in scientific discovery.
2. This house embraces uncertainty as a fundamental aspect of knowledge.
3. This house believes that we can never fully separate facts from interpretation.

Learners can be encouraged to engage with Du Châtelet's work in preparing for the debate and in crafting their arguments. Once students have gained a certain level of familiarity with Du Châtelet's arguments, teachers may wish to apply her ideas to other areas, such as ethics and political philosophy. In that case, we suggest debate motions such as the following:

4. This house believes that truthlike knowledge is essential for genuine happiness.
5. This house believes that post-truth politics mark the end of objective knowledge.
6. This house believes that cultural diversity enhances the construction of knowledge.

After using debates to explore Du Châtelet's epistemology, the juridical method can serve as a framework for writing an argumentative essay on one of the debate topics. In this essay, students can delve deeper into the arguments that intrigued them most during the debate, ultimately presenting their personal verdict on the debate topic in the conclusion, following Du Châtelet's juridical method.

These activities will ensure that learners acquire in-depth conceptual knowledge of Du Châtelet's epistemology and gain a deeper understanding of how its central concepts interconnect.

7.3 Procedural Knowledge

Du Châtelet's writings, particularly the rules extracted by Paganini (2022: 30-39) and outlined in paragraph 6, provide a valuable framework for constructing scientific knowledge. When learners follow the procedure outlined by the eleven rules, they experience the rigorous standards required of a scientific hypothesis. Additionally, applying Du Châtelet's rules to everyday topics offers a wonderful opportunity to engage creatively with hypothetical reasoning in the classroom. We propose the following three-step approach, which condenses the eleven rules into a concise checklist. For a more open-ended learning activity that allows for unexpected discoveries, step 1 could be left entirely to the learners. Alternatively, philosophy teachers could consider incorporating Du Châtelet's method into a cross-curricular project with a natural science subject, in order to explore the interplay between empirical observation and philosophical reasoning, and to highlight the historical development of scientific inquiry. In that case, the science teacher could provide the natural phenomenon in step 1, aligning it with the topic of the project. For instance, in a collaboration with biology, the question in step 1 could be: "How do trees transport water from the soil to their leaves?" After allowing learners to independently formulate a hypothesis in step 2, they can proceed to test their hypothesis in step 3.

Step 1. Ask yourself a question about a natural phenomenon, whose cause is unknown to you.
Step 2. Formulate a hypothesis that explains this phenomenon.
Step 3. Test your hypothesis by answering the questions below. 1. Have all relevant facts that are within your reach been collected? 2. Do all the consequences of the hypothesis align with the facts? 3. Would the phenomenon have been the same under different circumstances? 4. Can you think of a counterexample to your hypothesis? 5. Is your hypothesis open to revision, in the case of contrary evidence? 6. Are you not clinging to your hypothesis too much? 7. Have you considered that your hypothesis relies on probable statements that cannot be proved either logically (a priori) or empirically (a posteriori), and therefore should be approached with caution? 8. Can your hypothesis help to provide new explanations and predictions? 9. Have you considered that your hypothesis might be only partially right? 10. Is the hypothesis free from ad hoc assumptions made solely to protect it from falsification? 11. Is the hypothesis free from contradictions and do you consider it to be reasonably possible?

Tab 2: Scientific Inquiry

After implementing this three-step learning activity, a classroom discussion could serve to evaluate if the right hypothesis indeed passed the test, and if flawed hypotheses were rejected by Du Châtelet's rules. This evaluation phase could be further expanded by investigating how effectively the eleven rules can identify other flawed hypotheses. Learners could be tasked with describing the central hypothesis of a current conspiracy theory and applying the eleven questions to determine whether the hypothesis fails under scrutiny.

While moving from applying Du Châtelet's method to evaluating its effectivity, the focus shifts from procedural knowledge to metacognitive knowledge.

7.4 Metacognitive Knowledge

Metacognitive knowledge of Du Châtelet's work involves reflecting on hypothetical reasoning as a scientific method, critically assessing its strengths and limitations, and integrating these insights into a broader context that is meaningful to the learner.

An interesting question that a teacher might ask to stimulate this type of reflection is: "To what extent can the eleven rules be applied to Du Châtelet's own work?" In this case, the central hypothesis that is at stake might be: "Hypothetical reasoning is the best method we have to arrive at truthlike knowledge." Learners may be asked to go through the eleven questions once more, to thoroughly investigate if this hypothesis withstands its own test.

All of the learning activities described here, should be interpreted as invitations to learners to reflect on the fundamental philosophical question: "What is true and what can be found to be close to the truth?" We hope that these reflections will contribute to a deeper understanding of the nature and limitations of human knowledge, and that it will foster an attitude of intellectual humility and a deepened interest in scientific inquiry.

8. How can the Material be Implemented into a Traditional Canon?

Should the *Institutions physique* be included in the philosophical canon? The innovative character of this text in its time is still recognizable today and continues to be enriching for contemporary discussions. If the text is judged by its impact, it certainly belongs in the canon. The *Institutions physique* shows how important debates that extended into the 20th century were already outlined by Du Châtelet. Contemporary science is grounded in hypotheses, and the development of scientific thought from Du Châtelet to Popper can be meaningfully traced back to her contributions. (Paganini 2022 and Le Ru 2019)

There are several ways to incorporate this text into the canon, one of which is by comparing Du Châtelet's theory of knowledge with those of other prominent thinkers of her time – many of whom she boldly challenged. An excerpt from Descartes' *Discourse on method*, to which her text refers, is a suitable way to bring Du Châtelet into conversation with her contemporaries. It serves to illustrate the degree of critical epistemology from the first paragraphs of the chapter on hypotheses. (IP 4.53-55) Furthermore, her critique of observations as the foundations of universalities fits perfectly in an introductory lecture on the epistemology of John Locke's philosophy of empirical evidence. (IP 4.55-58)

Above all, the question arises as to why this impacting text has not yet been included in the canon, given that many later authors have been credited with the success of these methodological insights. It is, therefore, crucial to clarify in the classroom the reasons and consequences of this, as well as the many other cases of the exclusion of important texts, many of them written by women. These instances of gender inequality can be seen as benefiting those in positions of dominance, while also representing significant shortcomings for scientific progress, as the resulting loss of knowledge has adverse effects on society as a whole. Furthermore, the 18th century, notable for its groundbreaking inclusion of women thinkers, philosophers, and scientists (Hagengruber 2019), can be examined in comparison to the challenging and regressive tendencies observed in contemporary times. Considerable and impressive measures were taken at the time by people and institutions to discuss knowledge on an intellectual level, regardless of the gender of the knowledge bearer. Du Châtelet's high reputation throughout Europe proves that the debate was open then, perhaps even more open than today in some regards.

The exclusion of women led to a false cultural narrative, suggesting their absence from history was due to a lack of education and excellence. This perspective has been decisively disproven by the wealth of evidence now available. This "stolen history" (Hagengruber 2020) must be reclaimed – not only to advance science, but also to ensure access to the fullest and most accurate body of knowledge. This will reshape key aspects of the history of science and demonstrate that it is no longer a narrative authored solely by men. This revised story will also have an impact on social change, as written many years ago by Du Châtelet:

> If I were king, I would want to do this scientific experiment. I would reform an abuse that, in a sense, excludes half of humanity. I would let women share in all the rights of humanity, and especially those of the mind. This new system of education which I propose would be in every way favorable to the human species. (Du Châtelet 2009: 49)

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