From one Language to Another: Creativity in ‘English for Science’ and Innovation in Didactics of Sciences

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Abstract

This contribution is part of a project on university teaching literacy in English for science and focuses on how to construct knowledge that will be relevant to teachers of English for teaching in a scientific context. It aims to reflect on the relationship to language in science (particularly Latin and English) and its fundamental role in the process of elaborating science through some examples drawn from the history of science. Because the historical perspective allows us to understand how language in science was constructed. We will emphasise the creative potential of scholars and innovation in science by considering their multilingual skills, which allowed knowledge to advance by constructing it differently. Plurilingualism will be addressed in science insofar as English has become the language of international communication, which is not without consequences for the production and dissemination of science.

Keywords: Creativity, innovation, English for science, Latin, didactics
Introduction

This contribution aims to feed into the debate on literacy in English for science teachers (Author). LANSOD (languages for specialists in other disciplines) teachers, notably in science, do not always have the specialist knowledge and skills their students require to learn correct usage. More thought needs to be given to how to overcome this problem, as a sound grasp of literacy can be understood “as a dynamic tool for lifelong learning and professional development for specialist language teachers” (O’Connell & Chaplier, 2021: 99). We consider specialist knowledge and language skills together, in a didactic approach that takes the context into account.

In the following, we reflect on language and its fundamental role in scientific progress, through some examples drawn from the history of science. This diachronic perspective allows us to understand how language in science has been constructed over the centuries. As Banks (2019: 61) notes, “considering the historical development of language can help us understand how it works today”. It provides researchers with an insight into “[...] the concepts, theories and methods of the discipline, as well as to follow how the language of that discipline has been constituted and developed” (Celotti & Musacchio, 2004). Few studies have examined the use of language in science from a didactic perspective. We focus on the work of Francis Bacon, as he was active at a pivotal moment in history (the birth of empiricism), and paved the way for experimental science in the Anglo-Saxon context. The question we address is whether the choice of language has influenced the way science is thought about and constructed (Le Doeuff, 1991; Wildgen, 2000).

Creativity and innovation are integral to science. To be creative is to look at reality differently, and we can say that scientists have great creative potential. In this context, the multilingual skills of scientists have made it possible, at given moments in history, to advance knowledge by constructing it differently. Thus, we examine how the didactics of science have evolved in relation to the language and culture of creative and innovative scholars. This is only possible if we adopt a transdisciplinary position, as it can address complexity, and “seeks, beyond the disciplines, a vision of the human being as a whole and inscribed in the world” (Narcy-Combes & Narcy-Combes, 2019: 12). Consequently, we make several forays into the didactics of foreign languages and science, as well as the history of science.

1. Creativity and innovation

Although creativity and innovation are closely related and sometimes confused, they are different concepts. Creativity consists of having ideas, but not necessarily their systematic implementation. Innovation, on the other hand, consists of implementing an idea; it is a dynamic process that seeks to improve on the existing situation. Besançon and Chochoy (2013: 9) observe that, “innovation is seen as a remedy for the systemic crisis – economic, social, environmental and
cultural – that Western societies are facing”. It is not new: notably, Bacon ‘innovated’ in science due to tensions in the English university system.

1.1 Defining creativity

Creativity is a natural process that occurs when an individual needs to solve a problem, when existing conditions and solutions are insufficient, or when tried and true methods no longer work (cf. UNESCO, 2004). Capron Puozzo (2016: 15) notes that several myths surround the concept, “linked to history and society’s perception of it”. In the 17th century, creativity was associated with genius, a reflection of an innate and rare ability (Lubart, 2010). The scholars we refer to here were considered to be geniuses. Between the end of the 19th and 20th centuries, the myth of creativity as an exceptional characteristic was challenged. From this time onwards, several researchers examined the concept and analysed it in the light of their discipline. The first referenced definition of creativity comes from Guilford, a cognitive psychologist, who defines it as “the complexity and ability to generate new ideas” (Brown 2010: 14). In differential psychology, Lubart (2010:10) suggest that it is “the ability to produce something that is both novel and appropriate to the context in which it occurs”. Here, we focus on the latter understanding, notably the question of what language ideas are generated in.

Creativity is at the centre of each individual’s functioning, and supports adaptation to environmental changes (Rogers, 1959). The ability to respond to the complex problems of our time is increasingly sought-after. According to De Brabandère (2012), “creativity is the adequate ability of man in the face of the impossibility of not changing. It is the deliberate choice to be a mover rather than a victim, to lead rather than to suffer”. Creativity allows us to think about a world that does not yet exist.

1.2 Creativity and language

Language is the most precise tool available to the imagination, and supports intuitive and creative thinking. It governs conceptual, individual and cultural structures and argumentative strategies. It is only when using his or her native language that the researcher is able to use their intuition; all of the nuances, associations and connotations of a concept open up, allowing a network of images to emerge and flourish. As Krämer (2013: §9) underlines, “A malleable, flexible, adaptable and innovative native language is therefore indispensable for any research creativity”. The emergence of scientific discoveries at the end of the Renaissance was made possible by a scholar’s preference for their vernacular language rather than Latin: “Galileo thought in Italian, Kepler or Leibniz in German and Newton probably in English. Only the results of their thinking were published by them all in Latin” (ibid.). As Krämer goes on to say, the fundamental issue is that the producer of the idea understands it, hence the interest in expressing it in one’s native language, while, at the same time, it is clearly essential that the receiver understands the message.
Creativity in the scholar’s native language supports scientific invention and, in a way, innovation in the didactics of science. Gordin (2015) uses the notion of ‘identity’. When the speaker uses their native language, they can express themselves more clearly; thus, the choice of language is speaker-centric. Gordin also considers who the speaker is speaking to. Here, there is a need to use a language that the audience can understand, and that the speaker can use. Gordin terms this vehicular language ‘communication’. He specifies that it is audience-centric, and it is clear that the speaker tries to place him or herself on a continuum. “Today’s overwhelming dominance of one vehicular language may give the impression that science naturally trends toward communication and away from identity” (Gordin, 2015: 5). This was not always the case, at one point in history, scholars chose Latin, “deliberately and consciously” setting aside their native language.

For some languages, identity has been a longstanding issue. Tensions between identity and communication have always existed, even when scientific communication was only in one language. This pervasive feature of any exchange between people is greatly accentuated in the case of science, which is characterised by a high degree of intellectual creativity (identity) and social organisation (communication). This particular context allows us to see how creativity and social organisation interact in the spheres of language and language choice (ibid.). However, it should be noted that the dilemma is not always symmetrical, notably in the case of English speakers. Lévy-Leblond (2004:19) points out that 19th century science, in particular, “was characterised by intense language activity, engaging in inventive production and critical analysis of its vocabulary”. This contrasts with 20th-century science, which was not interested in language and even devalued it. This has had important epistemological and pedagogical effects, and has not supported creativity and innovation.

1.3 Creativity as a foundation for innovation

According to Ettlie (2000), the creative idea is the foundation of innovation. Brennan and Dooley (2005) point out that creativity is a personal and solitary process, unlike innovation, which is a social process. In the following, we illustrate how creativity has formed the basis for innovation by taking some examples from the history of science. In particular, we highlight the impact of the switch from Latin to the scholar’s native language (and vice versa) on science. If it is the native language that enables the creation of concepts, what can we say about 17th century scholars who wrote in Latin? Or did having to handle both languages avoid the fossilisation of knowledge?

1.4 Actor–network theory and the innovation process

The sociology of translation or the actor–network theoretical approach (Callon, Latour, Akrich in particular) see innovation in terms of a knowledge network. ‘Translation’ can be analysed as the process by which different actors negotiate and engage in dialogue around a common vision of a
problem that must be addressed, with a view to producing innovation. By changing the way science is done, and using ‘languages’, scholars have constituted a network that allows them not only to be creative and innovative at an individual (micro) level, but also to work together as a chain (macro), building on earlier work and giving rise to a new notion of progress (see below). The links between different actors, the object and the subject, have supported the development of innovation as a complex, non-linear, constantly evolving process, situated in the real world experience. The notion of mutual constitution is, therefore, fundamental.

2 Latin and university teaching

Galileo and Francis Bacon are only two of many emblematic figures in the scientific revolution. They were both the product of their era and, initially, reflected tradition before taking a different path. Latin was the scientific language of their time; it was taught in universities and was the international language used to disseminate findings. As Blair (2000) notes, it was the main vehicle of knowledge and culture.

2.1 University education in the Middle Ages

In the Middle Ages, the university curriculum consisted of the seven liberal arts, divided into two cycles: the trivium – grammar, rhetoric and dialectic; then the quadrivium – arithmetic, geometry, music and astronomy. The two cycles were preparation for a more advanced discipline: science. Scholastic methods dominated, which were based on a small number of authorities, including the Bible and Aristotle. Pedagogy was mainly oral, and focused on two activities: reading (lectio) and disputation (disputatio). However, students’ education was limited. Disciplines that were expressed in the vernacular (common law, literature) were not considered, nor were exact sciences. Experimentation did not exist, quantification methods were clumsy, and the mechanical arts were neglected (Verger and Charle, 2012). At this time, both the use of Latin and the scholastic method did not adapt to ongoing changes, and did not encourage creativity.

2.2 The first break: the decline of Latin and the rise of the vernacular

The first break occurred around the middle of the 17th century, reflected in two parallel movements: the decline of Latin as the language of scientific creativity, and the rise of the vernacular. The latter had already begun to become apparent during the Renaissance, but in the 17th century the issues were different.

During this period, the decline of Latin was due to the marginalisation of university education and the expansion of the practice of science beyond universities. Latin became a lingua franca that was detached from the scholastic method. While scholars continued to write in it, they began to use the vernacular openly. By the late Renaissance, depending on the field and the author, ‘sciences’ served both to develop the vernacular and accelerate the decline of Latin.
Language is used for thinking. As Pantin (2000) observes, by the end of the Renaissance several vernacular languages (French, Spanish, Italian and English) had become institutionalised. Notably, they were the primary means of expression, and even reasoning. At the same time, Latin texts retained their prestige, and the language was slow to disappear. At a certain moment, it became difficult for scholars to decide which language to use – Latin or the vernacular – especially as they were free to choose. During this time, the use of the vernacular marked a break with Latin and its thought system, and a move towards innovation. Not only did the use of the vernacular allow a wider audience to be reached, but it also brought about a cultural change in the way science was done. New disciplines (experimental sciences, engineering) emerged, and became more important in society. It could be said that at this time, scholars’ creativity was unleashed, and that a (scientific) method started to be established that paralleled the process of seeking the truth about natural phenomena.

3 The term ‘science’ and its use, a historical perspective

The term ‘science’ comes from the Latin word *scientia* and means ‘knowledge’, especially scientific, rational knowledge. *Scientia* was a philosophical notion, and referred to pure knowledge, in the sense of ‘knowing’. The word ‘science’ quickly took on the same meaning as the Greek term *episteme*, which means ‘certain knowledge’. Although both *scientia* and science existed in the Middle Ages and the Renaissance, they designated the equivalent of the Greek word *episteme*, which is concerned with ‘why’ questions. The latter was seen as noble knowledge, unlike its counterpart, *technè* (‘production’ or ‘material manufacture’), which was concerned with ‘how’ questions. It is clear that *scientia* does not have a practical aspect.

Blair (2000) argues that in the early modern period, the word *scientia* was more ambiguous than our present understanding. Not all disciplines were *scientia*. Theology, logic, physics and mathematics met the criterion, but astronomy and optics were called ‘middle’ sciences because they borrowed their principles from other disciplines, notably mathematics. Medicine and astrology lay somewhere between *ars* and *scientia*. Practical specialities such as navigation, accountancy, surgery and pharmacy were neither *ars* nor *scientia*, because technical knowledge was passed on by apprenticeship, often without leaving a written record. During the Renaissance, four categories were distinguished: *scientia, scientia media, ars* and *practice*. However, there were important divergences in this apparent continuity. Most were practised outside the university setting, and often taught in the vernacular rather than Latin. Consequently, this left little room for creativity in science within the university setting.

Finally, Gordin (2015: 3) notes the unusual narrowness of the English term ‘science’. In other languages, such as French (*science*), German (*Wissenschaft*) or Russian (*nauka*) the term includes scholarship in the broad sense.
4 The language of scholars – Latin, the vernacular and bilingualism

Blair (2000) notes that during this period scholars wrote either in Latin or the vernacular, depending on their profession, subject or the audience they intended to reach. Many were bilingual, and used this ability to their best advantage. This diversity emerged not only because of the complexity of the situation, but also because of the understanding of the concept of science. Despite the plurality of interpretations, the notion reflects a common vision that bases knowledge of nature on the conjunction of theory and practice, and mathematics and experimentation.

Latin dominated until the end of the Renaissance in various fields (Pantin 2000). Many of the scholars who contributed to the development of modern science wrote in the language, notably Copernicus, Brahe, Kepler and Galileo. Of those who wrote in English, the work De Magnete (1600) by William Gilbert and those by Harvey introduced the new experimental method in England. Between the end of the 14th and 17th centuries, scientific works published in English were of a more popular, pedagogical or practical nature (Banks 2008). The meaning of the term ‘science’ began to change, before it took on its modern meaning at the end of the 19th century.

At this time, humanism probably played as much of a role as academic habits in maintaining Latin’s status as a multi-purpose scientific language. Humanist scholars used their bilingual/plurilingual abilities cautiously and, in times of upheaval, retreated to Latin. It is difficult to explain this diversity in terms of objective linguistic choices such as cultural roots, genre norms, or an orientation towards a given audience. Nevertheless, according to Pantin (2000), at the beginning of the 17th century there was a clear shift to the vernacular. At this time, the Scientific Revolution reflected the development of rigorous intellectual activities and national languages, which were considered to be vectors of modern culture. Some examples of this legitimisation of national languages from the first half of the 17th century are Descartes (French), Harvey (English) and Galileo (Tuscan).

Wildgen (2000) observes that between 1515 and 1630, numerous philosophers had adopted an anti-Aristotelian attitude, and sought to innovate. A leading example is the philosopher Giordano Bruno, who was a scientific innovator and had the courage to use his native language (he wrote in Italian). At this time, sciences were formed in parallel with a linguistic and sociolinguistic evolution.

5 The creative power of language and innovation in science

We illustrate our arguments with the example of the English philosopher Francis Bacon. Although he wrote many works in Latin, many others were written in his native language, English. In the latter case, the aim was to communicate scientific knowledge that broke with traditional teaching in universities. Does his writing become more creative when he writes in his
native language, seeking to address a wider audience? Or, on the other hand, when he writes non-scholarly works in Latin? Can we identify an innovative didactic of sciences that breaks with the scholastic method taught to a restricted circle of Latin speakers?

5.1 Francis Bacon

In addition to a career in law and politics, Bacon contributed to science, philosophy, history and literature. An opponent of scholasticism, he is seen as the father of empiricism. His criticism was directed primarily at Aristotle, and he sought to establish a solid foundation for his new philosophy based on experimentation that would replace Aristotle’s. Bacon understood the need to reconstitute the system of human knowledge on new foundations. His main works are: *The Advancement of Learning* (1605); *Instauratio magna* (1620); *The New Atlantis* (published after his death in 1627).

He wrote an encyclopaedic work in Latin, *Instauratio magna scientiarum*, which was intended to consist of six parts. The first and third parts were begun, but only the second part was completed. It should be noted that his two main works are one and the same under the title *Instauratio magna: De dignitate et augmentis scientiarum and Novum organum scientiarum*, which appeared in 1620. In a way, it could be said that he reinvented science, but a lack of time, and his political duties meant that Bacon did not put his own theory into practice. Nevertheless, his theory proved to be very fruitful, and he is at least partly responsible for the retreat from scholastic thinking and the beginning of scientific reasoning based on empiricism.

5.2 Bacon’s use of languages in The Advancement of Learning

Bacon began to disseminate his ideas about how to create a new way of thinking in his work *The Advancement of Learning*, first published in English in 1605. Unfortunately, his thoughts were not understood by King James I, its recipient, because it advocated the promotion of science through the promotion of Bacon himself. Nor was it particularly successful on the continent, because few people could read, or think in English at that time (Le Doeuff, 1991). Latin remained the language of the educated. He translated his book into Latin in 1623, and the translation is much more extensive than the English version, as he wanted to reach a wider audience. In 1624, he had the work translated into French. Fattori (2014) notes that Bacon had travelled to France as a young man, and had fond memories of the country. He had a good knowledge of French and the country’s laws, along with European politics (Fattori, 2014).

5.3 Bacon’s notion of progress

To understand the scope of Bacon’s aims, we must first consider the notion of progress, and how linguistic creativity has generated innovation in science. The idea of scientific progress, or rather the idea that there has been continuous scientific progress for several centuries, is deeply rooted
in our modern society. It is generally associated with technological development, which has been particularly striking since the second half of the 20th century. However, scientific progress did not exist in Bacon’s time, and his goal was to progress knowledge (cf. scientia). In the 17th century, the prevailing vision was of a world in decline. For example, in the domain of medicine, it was difficult to compete with the ideas put forward by Aristotle and Galen. At this time, it was only considered acceptable to interpret or reinterpret the ancient texts that had been in use for centuries. Innovation was complicated, because it meant questioning what had been said and done. It was therefore difficult for these new ‘scientists’ to find a place in the academic system. Change happened slowly, and innovation occurred outside universities (Banks, 2008).

In The Advancement of Learning, Bacon argues that the only important knowledge is that which can be discovered by observation. He proposes a new path for science that should, eventually, lead to real progress. In other words, he aimed to “libérer l’invention” (Peterschmitt, 2014). Bacon’s approach was dynamic; he proposed building on the past, to avoid errors and invent. His philosophy combines the old and the new. His strategy was that “… progress must be infinite and […] it is impossible to determine a priori the path that must be followed to produce new knowledge” (Peterschmitt, 2014: 1). In contrast to the scholastic method, knowledge is not known in advance, and this marks Bacon’s innovative approach. He does not follow the ‘method’ – the path laid out in advance. One important consequence of this attitude is that science is no longer presented in a systematic way, as an illusory globality that prevented progress. Instead, he builds on existing knowledge, and adopts an inductive approach to form a new knowledge where the rules have to be invented (ibid.).

The word ‘progress’ does not appear in his Latin text, but the equivalent is found in the periphrase “to push back the narrow limits of man’s power over the universe” (“humani in universum imperii augustias... [proferre]”). What is new in this text is that it presents the state (in particular, the king) as the main actor in progress. This was for both politico-religious (the sovereign was the head of the church), social (the welfare of the population) and practical (cost) reasons. This conceptualisation of progress was innovative and implied a radical break with the cultural heritage of the time. The idea that knowledge could be ‘on the move’ was new. In French, English and Latin, the terms progrès, proficiency and progressio, respectively, describe a journey, the progress that a student can make in a discipline, or moral betterment. In broad terms, it conveys the forward movement of an individual in space. The journey is one of Bacon’s favourite themes, and is found in many of his works, it is thus, “…always a metaphor for progress and the advancement of knowledge” (Popelard, 2006: §11).

If we examine his book’s full title, Of the Proficience and Advanceme...
“progression and proficience”, “proficience and augmentation”. ‘Advancement’ encompasses the idea of help in moving forward (c. 1300, *avancement* is found from the Old French word *avancement*, to refer to, from 1550 “the act of helping to move something forward”). ‘Proficiency’ is not in the English etymological dictionary and, in the 1540s, meant ‘advancement’ or ‘progress’, although the idea of forward movement is more static than in ‘advancement’. On the other hand, the title does not mention the notion of knowledge, but does use learning, indicating that Bacon envisaged the acquisition of knowledge through a change in learning methods, notably the transmission of knowledge from teacher to pupil (see below).

In the text, the idea of forward movement is expressed with the following terms: ‘proficience’, ‘proficiency’, ‘advancement’, ‘progress’ and ‘progression’. *Proficience* appears eleven times, and is associated with learning, nature, knowledge and science (Noun of Noun), along with progression and augmentation (with “and”). *Proficiency* appears only once. *Progress* is mentioned four times, and is qualified by adjectives that reflect the Baconian project of endless scientific reform, both deep and plural; it is also associated with proficience (with ‘or’). The term suggests a dynamic approach (from the word *progresse* found at the beginning of the 15th century, derived from the Old French word *progres* and the Latin word *progressus*). Its figurative meaning (which emerged around 1600) includes a limited notion of going further, suggesting that there are several stages (advancement to higher stages). The word *progression* also appears relatively frequently (11 times) and is associated with science, philosophy and learning (Noun of Noun), along with the notion of moving to another stage (see the late 14th-century word *progressioun*, “the action of moving from one condition to another,” derived from the Old French word *progression* and the Latin word *progressionem*). *Advancement* appears 14 times, and is often associated with learning or knowledge.

In 1624, his work was translated (at his request) into French by André Maugars, and published in Paris under the title *Le Progrez et avancement aux sciences divines et humaines*. The expression the ‘progress of science’ does not appear in the title, because it would have been inappropriate at the time. The French word *progrès* is borrowed from the Latin word *progressus* (“march forward; the development of things; increase”), and the production of knowledge was irrelevant. The phrase, “the progress of science” does appear in the text, showing that it was easier to innovate in the book’s text than in its title. The translator points out to the reader that he was required to create new expressions, following the author, who “invented in his own language” (Le Doeuff, 1991). Maugars does not specifically mention the progress of science; instead, he says that the book is a treatise on the “division of sciences”, and a remedy “to heal the wounds” that have been done to the sciences: he says that they have undergone an “alteration” and it is a question of “restoring them to their first splendour”.

While the notion of progress is absent from both the book’s preface and title, this does not mean
that there is no forward march of science—it exists, but under a different approach. One example is the advent of optics in the 13th century, which built on earlier work that addressed a new question and resulted in new knowledge. As Le Doeuff (1991) points out, this approach is part of a chronology. At the time, these events were conceived as products and not processes: they were discoveries, indicating that the previous scientist was ‘wrong’. This reflects the idea that the concepts of inventor, *inventio* (the action of discovering, finding, discovery), invention (borrowed from the Latin *inventio*) and discovery are synonymous.

“This concept focuses on the founding act, the first discovery, and it also fixes the figure [...] of the author of the invention. The notion of the progress of knowledge, on the other hand, presupposes a certain erasure of the figure of the author, each one being then like a link in a long chain” (Le Doeuff, 1991: XIX).

Bacon broke with this approach by pointing out that the progress of science would be prevented if the author of the invention is given precedence. He thus clearly distinguishes the event from the process of the constitution of science. Bacon’s ultimate aim was to reform all existing knowledge, and thus change the way in which way universities positioned themselves with respect to knowledge. He underlined the idea of a network of knowledge founded on a collegiality of scholars. His ideas would lead to the emergence of a new understanding of the progress of science (Fattori 2014). In seeking to be seen as a guide, he sets a new direction, establishing the conditions for progress. “What follows is and can only be the work of knowledge itself, which will pave its own road as it moves forward. The Baconian logic is therefore that of a science in the making” (Peterschmitt 2014: §46). It could be said that all of the ‘scientists’ who followed Bacon are inventors, in the sense that they contribute to an ongoing process by finding solutions. “Scientific knowledge has been constituted progressively by accumulation of inventions of solutions, and by the construction, the style, which structures it into a knowledge” (Cifoletti, 2000:96).

### 5.4 René Descartes

René Descartes was a French mathematician, physicist and philosopher who sought to renew philosophy, reject all scholasticism, and base metaphysics on a method used in mathematics. In 1637, he published three short extracts from his scientific work: *Dioptric, Meteors* and *Geometry*. These extracts are accompanied by a preface that has remained famous: *Discourse on the Method* (DM). The discourse was remarkable because it was written in French, while Latin was the language of scholars. Although writing in French was not uncommon at the time (cf. Montaigne’s *Essais*) the DM is easier to understand and more accessible because it consists of an intellectual autobiography (with no Latin quotations).

Descartes does not seek to teach his method; instead he tries to explain its genesis. This is
because it is inseparable from the scientific experimentation that implements it, and provides its justification. He presents his method to the public for scrutinization. The decision to use the French language is related to Descartes’ definition of reason: he sees it as a faculty that all possess, not just the educated. He therefore believes that reasoning is an act that does not require culture. French, as a language, is linked to the country of France: it is for those who use ‘their pure natural reason’. Latin, on the other hand, is the universal language of scholars.

Descartes translated the DM himself into Latin in 1644. This showed that the original had had limited success with the general public. The Latin version was twice as popular as the French original, as it was principally scholars who were interested in his writings. This may have been due to the heterogeneity of his work. He does not claim to teach or explain his method, only to say something about it: this is why he calls it a ‘discourse’ and not a ‘treatise’.

5.5 Linguistic creativity and innovation in science didactics: the term ‘method’

Let us examine the concept of the ‘method’, which is a key notion in epistemology and science, and then compare how it is used by Descartes and Bacon (writing in French and English, respectively). Our aim is to see how creativity is manifested through the use of language, and how innovation can be observed in the way science was conceived. We draw on an article by Philippe Hamou (2014).

Bacon had recognised that the main obstacle to the advancement of science lay in the wrong methods being adopted. He opposed scholasticism, which was limited to the interpretation of classical texts, and supported the idea of interpreting nature, where the direct observation of facts enriched knowledge. He proposed a new path that represented a shift from syllogistic argumentation towards the method of induction. He wanted to abolish sterile speculation, and hoped that science would constantly increase mankind’s power through its useful application. He was probably the first person to envisage this positive aspect of science.

We begin by considering the definition of the term ‘method’ as a function of the period. From an etymological and historical point of view, the term comes from the Low Latin word methodus (a scientific term found in medicine, rhetoric and geometry), which is borrowed from the Ancient Greek methodos. In 1537, it had a medical meaning; in 1546, it is defined as a “set of reasoned procedures”; and in 1547, it is a “way of teaching”. It was in 1637 that the term took on a philosophical meaning, in Descartes’ DM.

At the beginning of the 17th century, ‘method’ was based on the Greek methodos, the “pursuit or search for a way”. This classical concept described the way of organising knowledge (the “art of arrangement”, which comes after invention and judgement). Content is already constructed, and the teacher transmits it. There is no notion of producing knowledge. The meaning of the term is
pedagogical, and this understanding continued to dominate at the beginning of the 17th century. However, beginning with Descartes and Bacon, the idea of a “method of invention”, in the sense of the search for a proof began to emerge. In the early modern era, “method includes this idea of a formal discourse that precedes science and directs it, prescribing in advance the stages of research and the procedures of control” (Hamou, 2014, 1): in other words, the scientific method.

It is interesting to compare the way Bacon and Descartes relate to the concept, with reference to two aspects: lexical and conceptual (the way of conceiving). Reflecting his own way of invention, based on induction, Bacon never uses the term methodus and rarely uses method. The latter had both a medical (early 15th century) and a travelling meaning. From 1580 onwards, it takes on the meaning of an organisation that aims to meet a precise goal. However, this meaning put an end to any future growth of knowledge. Bacon prefers to call this path via, ratio or inductio, as in the Novum Organum. Via is the way, but also the journey and, figuratively, it has the meaning of a method of practical exercise.

The first meaning of ratio is associated with accounts, but it is also the faculty of calculating, reasoning and judgment. Bacon also opposed the use of the term methodus (a formal and systematic term used in textbooks), preferring ratio. On the other hand, when he does use ‘method’, he gives it the meaning of the art of transmitting knowledge that was current at the time (Advancement of Learning): "the method of the mathematics", "And such is their method, that rests not so much upon evidence of truth proved by arguments ".

Descartes, unlike Bacon, gives the word ‘method’ a new meaning. First, he rejects the idea that knowledge is transmitted by a master, and favours self-teaching. In the DM he introduces this idea.

Both Bacon and Descartes consider the concept of the method in the same way, namely, as the art of transmission. It could therefore be said that they are not really innovative, but instead give the idea a new meaning, because they fundamentally change the very idea of what it means to learn a science:

- It is not received as an already-completed edifice (teacher-centered),
- People produce it themselves through their own intellectual effort (learner-centered).

This can be seen as a renewal of the notion of the didactics of science through languages: from teacher-centered to learner-centered.

Bacon and Descartes agree on another aspect: the best teaching does not show the objects of knowledge, which are organised into a body of knowledge that the learner can easily memorise. Instead, it shows the learner “the way in which the knowledge one teaches was invented” (Hamou 2014). The overriding aim was to answer the question “how can a person educate him or
herself” in a time of change. Scientific knowledge could no longer be based solely on that of the past, but was seen as having to be constructed, by and for future generations. Consequently, teaching at universities, which was based on authority and method, needed to be changed.

Descartes and Bacon diverge with respect to their conception of the instruments and techniques that should be used to implement the method, which reflects their anthropological origin. Descartes uses the term ‘method’ in the sense of the art of inventing. The method is a process that allows the mind to guide the individual; it produces its own instruments that it has tested rigorously. This provides the foundation for his proposal that knowledge should progress by means of deduction, which is a movement of thought. For his part, Bacon does not use the term, but employs technical and organological metaphors: a compass, a ruler and compass, an elevating machine.

There is, therefore, a clear epistemological difference with respect to objectives: the Cartesian ideal remains humanist, the Baconian project is transhumanist. It can be said that Bacon and Descartes have two very different conceptions of mankind. Descartes believes that humans have the faculties to teach themselves. Bacon, on the other hand, conceives of the human mind as perverted; man cannot manage on his own and will lose his way. Consequently, he cannot teach himself, he must call on external support.

At this time a movement – writing both in Latin and in the vernacular – was becoming widespread. It is clear that the choice of language influenced scientific development, and vice versa. The use of a particular language always involves relying on a system of norms that structure thought and its relationship with the world.

6. Bacon’s linguistic and cultural influences

According to Banks (2008), Bacon was not a real scientist, but he had a considerable influence on the way science was done, and how scientists subsequently wrote and described their experiments in English. This is partly due to the way Bacon conceived of science and scientific writing. In the following, we discuss the creativity of Robert Boyle and Isaac Newton in their use of language, first with respect to the narrative style they adopt (sceptical rhetoric), and secondly the influence of Latin on English, and vice versa.

6.1 Boyle’s sceptical rhetoric

Boyle was a leader in experimental physics, and a pioneer of modern science in England in classical times. He was one of the first to put Bacon’s project into practice, and to write in English. He chose the platonic dialogue in The Sceptical Chymist (1661), which is written in English. This allowed him to express his own ideas through the words of a fictional character, thus avoiding direct criticism. Popkin (2003) speaks of ‘constructive or mitigated scepticism’, as
Boyle features the character of Carneades and speeches that he describes as ‘sceptical’. According to Grima-Morales (2014), this adjective reflects a specifically British culture in relation to the question of the scientific method. Boyle realised that scholars needed a new form to express their ideas, and to convince a sceptical readership of the validity of the new method. He attacked the alchemists for their obscure statements, and insisted on the need for rigour in the conduct of experimental research. He thus adopted a sceptical strategy, and in so doing showed the theoretical limits of the chemistry of his time, while retaining its practices and knowledge. Boyle’s chosen genre was the experimental essay, a new form with characteristics that remained to be established. He actively contributed to producing a new vocabulary based on the nominal, which he believed was necessary given the precision and clarity of this new genre (Banks, 2008).

6.2 Newton and the influence of Latin on English

In 1669, Newton became Lucasian Professor of Mathematics at Cambridge, at the age of 26, and continued to hold his position until 1701. He held strong religious beliefs, and was not only a Puritan but also a Unitarian. He took care to conceal this affiliation, which was a criminal offence at the time. He was influenced by the culture in which he was educated and worked, and this had an impact on the language in which he wrote (Banks, 2008). For example, he wrote his *Philosophiae Naturalis Principia Mathematica* (1687) in Latin, but wrote *Opticks* (1704) in English, which contributed to the development of a vernacular scientific literature.

Halliday (1987) considers that it was from this point that scientific English was born, in the sense that Newton introduced the discourse of experimentation. According to Banks (2008:58), “Newton’s English writing, and the innovations it contains, was influenced by the Latin that he and other scientists wrote”. Banks (2008) points out that this possible influence of Latin (on English) has rarely been considered. This could be a consequence of his position as an empirical scientist. Newton used the process of nominalisation in his work in English, which would be translated from scientific Latin. Halliday (1987) sees nominalisation as the cornerstone of scientific discourse. The Latin used by Newton would have had an influence on his writing. Banks (2008) suggests that Newton’s Latin could have been influenced by his native English. He suggests that intellectuals who had a wide range of native languages used Latin as a *lingua franca*, implying that the influence of these languages on Latin was attenuated, since the more Latin was influenced by other languages, the less it would be used as a *lingua franca*. As Banks (2008:63) notes, “there is probably a complicated and two-way influence between Latin and English in scientific writing of this period”.

6.3 Newton and Huygens: ideological differences

According to Banks (2004), the texts (*Opticks* and *Traité de la lumière*) of Newton and Huygens show linguistic differences that reveal epistemological differences. Christian Huygens, an
important figure in the history of physics and a Dutchman, was called to France by Colbert to give prestige to the new Academy of Sciences and enable it to compete with the Royal Society in London. A great rivalry between the two academies would be established through the intermediary of scientists. In London, Newton set about writing a treatise on optics to describe and explain light phenomena (corpuscular theory). In 1675, he completed the first part of his work, but the whole was not published in English until 1704, and a Latin translation appeared in 1706. In 1690, Huygens published his Traité de la lumière (wave theory). They were both philosophers in the sense of the time, but they did not practice the same philosophy. Newton was engaged in experimental philosophy, derived from Bacon. Huygens focused on a mechanical philosophy that follows the Cartesian precept.

In the first paragraph of his book (1979 (1730): 2): “My Design in this Book is not to explain the Properties of Light by Hypotheses, but to propose and prove them by Reason and Experiments”, Newton rejects the notion of the hypothesis, which is the basis of the Cartesian method. He places himself in opposition to the Cartesians. On the other hand, Huygens (1992 (1690) :52) writes:

“J’essaierai donc dans ce livre, pas de principes reçus dans la Philosophie d’aujourd’hui, de donner des raisons plus claires et plus vraisemblables, premièrement de ces propriétés de la lumière directement étendue, secondement de celle qui se réfléchit par la rencontre d’autres corps”.

Huygens refers to the Philosophie d’aujourd’hui, i.e. to Cartesianism. Their views on methods are therefore different from the start. With Newton, the argument is based on experience, i.e., someone does something; with Huygens, no one does anything, the facts are known, and reasoning takes place on the basis of these facts.

The use of personal pronouns (Newton uses ‘I’; Huygens ‘je, nous, on’) and process nomenclature attests to the different positions of the authors. Newton’s philosophy is empirical in the spirit of Bacon and his contemporaries. These thought processes are inductive. Huygens’ philosophy is Cartesian and therefore deductive. Banks (2004:11) sees this as ideology which “filters down to the level of lexicogrammar, thus affecting the way in which the language is encoded”.

Conclusion

What does this diversion into history bring to science and language didactics?

This historical exploration illustrates the cultural (anthropological, religious) specificity of each educational system and, therefore, the crucial role of language. The use of French, English or another language refers to a system of thought and a culture that are specific to each linguistic
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group, both in science and in other life activities. Language and culture influence the way science is done, as we have seen with the example of Bacon. Because a person’s idea of science (e.g., Bacon’s idea) controls the way that the person practices science (e.g., the method), we can speak of the didactics of science through language. The philosophy of knowledge (empiricism, rationalism) is part of the scientific process, and it is relevant to include it in the development of the concept of English for language teachers in science. By changing the representation of knowledge (e.g., that of language and science teachers), knowledge behaviours are changed (the didactic perspective). There is a need to reintegrate the thinking dimension with language in the teaching of the language of science. “Tell what you speak, and I will tell you what you think” (Gordin 2015:14).

Many believe that language is transparent and, therefore, that language diversity is a negligible factor in the emergence of new ideas in intercultural communication (Holden, 2002). This is not the view of Piccardo (2016), who advocates the idea of taking plurilingualism and linguistic diversity into account in the construction, transmission and circulation of knowledge. The notion of plurilingualism/pluriculturalism is complex and underlies a creative potential, which research is gradually confirming (Piccardo, 2016).

In an age of multilingualism, the imposition of English as a lingua franca in scientific research tends to make researchers monolingual, and thus restrict their creative potential. In the past, scholars were multilingual, inventive and creative. "The collapse into monolingualism is, historically speaking, a very strange outcome, since most of humanity for most of its existence has been to a greater or lesser degree multilingual" (Gordin 2015:2). Frath and Herreras (2017) argue that plurilingualism has turned into monolingualism in the form of ‘anglicisation’, along with a uniform (American-style) culture in scientific research and teaching in European universities.

However, we have seen that linguistic and cultural diversity has been a lever for creativity in the work of scholars of the past, and this is confirmed by neuroscientific research on the cognitive connection between creativity and plurilingualism (Furlong, 2009). Plurilingualism and pluriculturalism have a place in the scientific world, and can help researchers to develop their creative and innovative potential that enriches knowledge. Our reflection on language and Latin from a historical perspective invites further examination of the effect of the choice of a language on the production and dissemination of knowledge in the current scientific community, where English dominates as the vehicular language.
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Boek.


