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**UNLOCKING SOLUTIONS:
LITERARY ENIGMAS AS CATALYSTS
IN FOSTERING PROBLEM-SOLVING SKILLS
FOR A GLOBAL CITIZENSHIP**

TESI DOCTORAL

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Realitzada per:

Laura Vela Serrano

Dirigida per:

Dra. Julia Haba Osca

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Dr. JULIA HABA OSCA, Ph. D. Senior Lecturer at the Department of English and German Philology at the Faculty of Philology, Translation and Communication of the Universitat de València

HEREBY CERTIFIES

that the doctoral dissertation entitled:

UNLOCKING SOLUTIONS:
LITERARY ENIGMAS AS CATALYSTS
IN FOSTERING PROBLEM-SOLVING SKILLS
FOR A GLOBAL CITIZENSHIP

has been carried out by LAURA VELA SERRANO under her supervision and constitutes the doctoral dissertation to qualify for the academic degree of Doctor. For the record, and in compliance with current legislation, I present this report by presenting this certificate in Valencia, March 2024.

Dra. Julia Haba Osca

International Doctorate Mention

This thesis holds the International Doctorate mention, which is only applicable to doctoral degrees regulated according to R.D. 99/2011.

1) In order to obtain the International Doctorate mention, the PhD student has completed a 3-month stay abroad at the University of Surrey (United Kingdom). Prof. Dr. Patricia Pulham was responsible for the supervision of the student at said institution and the stay was authorised by the Academic Committee of the Doctoral Programme in Language, Literature and Culture, and its Applications (code 3135). This stay was part of the fulfilment of the PhD student's activities.

2) Catalan has been employed as the second language to meet the next requirement of the International Doctorate Mention as well as in part of the PhD Viva due to its pivotal role in the Valencian Community's cultural development. The rationale of the study, methodology, discussion and conclusions in Catalan are attached in Appendix 10.1.

3) Professor Beth Palmer from the University of Surrey (United Kingdom), who has not been responsible for the stay abroad, will be part of the Thesis Assessment Committee (Panel).

A la meua germana Silvia,

l'estrela més brillant

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Knowledge was that incandescent glow for me, tarnished but so grand. I have always been equally fascinated and irritated by those things that I could not understand. Deconstructing my own beliefs, analysing data and discerning patterns within streams of information feel central to the way I see life. Therefore, doing a PhD did not come as a surprise to any of the following people, whose support has been crucial throughout this entire process.

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This is an ode to what navigating the academic waters has looked like for me. To growing personally, gaining valuable professional skills, and finally grasping something after long hours of research, but also to the sleepless nights and self-doubt. This is an ode to what keeps me up at night, to the mysteries I long to discover the answer to and those which I embody myself – though cryptic and Machiavellian at times, I now choose to step into the daylight and let it go.

Unlocking Solutions: Literary Enigmas as Catalysts in Fostering Problem-Solving Skills for a Global Citizenship

Abstract

Problem-solving is an ever-present factor in everyday life, sometimes screaming at the top of its lungs and sometimes hiding in plain sight. The interdisciplinary nature of its study allows the solver to explore its diverse applications, thereby comprehending its significance by deciphering intricate scenarios and transforming them into manageable mental constructs for practical use. From a holistic approach in British fiction and non-fiction, literary enigmas – such as ciphers, puzzles, or secret communication – are introduced as a potential tool to develop this ability. Alongside the evolution of the concept of problem-solving and its potential neurological benefits, this study explores a spectrum of real-world manifestations, spanning from Lewis Carroll's ciphers to the crucial role of codebreaking at Bletchley Park during WWII.

Far from being merely a source of entertainment, a significant aspect of solidifying problem-solving skills lies in their practical application to real-life challenges, with the overarching goal of fostering Global Citizenship for the Sustainable Development Goals (SDGs) serving as the primary objective of this work. Given the pressing urgency of these challenges on a global scale, the acquisition and refinement of problem-solving abilities can serve as a linchpin in the efforts to address climate change and social injustice. This thesis posits that such skills can be honed through a literary lens, while remaining applicable across various disciplines, enabling individuals to effectively interpret and resolve adverse situations in real-world contexts.

Keywords: problem solving, literary enigmas, British Literature, Global Citizenship, SDGs

Desbloqueando Soluciones: Enigmas Literarios como Catalizadores en la Resolución de Problemas para la Ciudadanía Global

Resumen

La resolución de problemas es un factor siempre presente en la vida cotidiana, que a veces grita a todo pulmón y otras veces se esconde a plena vista. Su estudio desde diferentes disciplinas permite relacionar sus aplicaciones y comprender su valor desentrañando situaciones complejas para convertirlas en una representación mental con la que poder trabajar. Desde un enfoque holístico en la ficción y no ficción británicas, los enigmas literarios – como cifrados, acertijos o comunicación secreta – se presentan como una herramienta para desarrollar esta habilidad. Junto con la evolución del concepto de resolución de problemas y los efectos neurológicos positivos que puede tener, se analiza un abanico de situaciones, desde los cifrados de Lewis Carroll hasta el papel fundamental de decodificar mensajes en Bletchley Park en la Segunda Guerra Mundial.

Lejos de ser simplemente una fuente de entretenimiento, un aspecto importante de las habilidades de resolución de problemas radica en su aplicación práctica a los desafíos de la vida real, con el objetivo general de fomentar la Ciudadanía Global para los Objetivos de Desarrollo Sostenible (ODS). Dada la urgencia apremiante de estos desafíos a escala global, la adquisición y el perfeccionamiento de habilidades para resolver problemas pueden servir como eje en los esfuerzos para abordar el cambio climático y la injusticia social. Esta tesis postula que dichas habilidades pueden desarrollarse a través de una lente literaria, sin dejar de ser aplicables en diversas disciplinas, lo que permite a las personas interpretar y resolver eficazmente situaciones adversas en contextos del mundo real.

Palabras clave: resolución de problemas, enigmas literarios, literatura británica, Ciudadanía Global, ODS

Desbloqueig de Solucions: Enigmes Literaris com a Catalitzadors en la Resolució de Problemes per a la Ciutadania Global

Resum

La resolució de problemes és un factor sempre present a la vida quotidiana, que de vegades crida a tot pulmó i altres vegades s'amaga a plena vista. El seu estudi des de diferents disciplines permet relacionar les seues aplicacions i comprendre'n el valor desentranant situacions complexes per convertir-les en una representació mental amb què poder treballar. Des d'un enfocament holístic en la ficció i no ficció britàniques, els enigmes literaris – com ara xifrats, endevinalles o comunicació secreta – es presenten com una eina per desenvolupar aquesta habilitat. Juntament amb l'evolució del concepte de resolució de problemes i els efectes neurològics positius que pot tenir, s'analitzen algunes aplicacions pràctiques, des dels xifrats de Lewis Carroll fins al paper fonamental de descodificar missatges a Bletchley Park a la Segona Guerra Mundial.

Lluny de ser només una font d'entreteniment, un aspecte important de consolidar les habilitats de resolució de problemes rau en la seua aplicació pràctica als reptes de la vida real, amb l'objectiu general de fomentar la Ciutadania Global per als Objectius de Desenvolupament Sostenible (ODS). Donada la urgència urgent d'aquests reptes a escala global, l'adquisició i el perfeccionament d'habilitats de resolució de problemes poden servir de clau en els esforços per abordar el canvi climàtic i la injustícia social. Aquesta tesi postula que aquestes habilitats es poden desenvolupar a través d'una lent literària, mentre segueixen sent aplicables a diverses disciplines, permetent als individus interpretar i resoldre de manera eficaç situacions adverses en contextos del món real.

Paraules clau: resolució de problemes, enigmes literaris, literatura britànica, Ciutadania Global, ODS

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1. Rationale of the Study

The incandescent glow for knowledge has persisted throughout time, giving headaches to humanity when attempting to grasp the answer to the greatest mysteries in life and becoming a frustrating yet thrilling task when they remain unsolved. Understanding how gravity works or deciphering the first numeral system based on multiples of ten by the Egyptians were breakthroughs that changed life forever, but there are still questions that haunt people's minds when staring at the ceiling at night, such as whether there might be life outside the Earth, what caused the fire in The Great Library of Alexandria, or how to slow the advance of Alzheimer's disease. The enigma that one might lose sleep to, however, does not have to be a major issue, but can appear on a daily basis, from designing a marketing strategy to an unexpected heartbreak, where a latent longing to see them come back fades in the day.

Regularly, humans encounter situations that are not straightforward to solve, and developing the skills to manage them effectively is as important as adapting them to slightly different problems that might occur in real life (Fischer et al., 2012; Prastika et al., 2020). Problem-solving encompasses a complex set of abilities, such as critical and lateral thinking or decision-making, that activate when identifying data and prioritising and selecting alternatives (Schnotz et al., 2010; Birgili, 2015). This process requires an untying or loosening that depend on the ability of understanding principles, theories, or models through previous experiences (Kim & Grunig, 2011; Bassok & Novick, 2012). Traditionally, research has often confined their study to mathematics or limited their application to the workplace. However, there remains a dearth of research examining them as a set of transferable skills applicable to major issues such as the Sustainable Development Goals (SDGs) by the United Nations, which still exhibit significant knowledge gaps (Zimm et al., 2018; Allen et al., 2019; Kathambi, 2023). Acquiring a Global Citizenship mindset—that is, an awareness of interconnectedness and a commitment to contributing positively to the well-being of humanity and the planet as a whole (United Nations, n.d.)—is crucial to contribute to these goals.

Due to the emergency state in which the world is in right now, helping to develop a Global Citizenship mindset through different means is an

urgent call for everyone (United Nations, 2015; Perkins et al., 2022; Fulzele et al, 2022). Thus, this does not necessarily mean that these skills can only be built through literary enigmas as analysed in this thesis, but rather, that it is one of the ways to do so – furthermore, the enigmas are classified as “literary”, but are not exclusively fiction. Hence, several types of problems such as enigmas, ciphers or riddles are included within the theoretical framework of this thesis, which is divided into an overview of problem-solving in British literature and an evolution of the concept itself. This section is followed by the methodology and four case studies that depict several ways to apply this skill: Sherlock Holmes’ reasoning method, Lewis Carroll’s constant practice, Ada Lovelace’s attempt at drafting the first algorithm ever and codebreaking in Bletchley Park during the war.

While some other periods could have also been studied, the Victorian and post-Victorian era were thought to provide great examples of how the steps when solving a problem unfolded. There was a peak interest in enigmas, puzzles and secret communication that they experienced, a time where seemingly unrelated disciplines such as science and spiritualism coexisted (Pavlik & Regret Iyer, 2023). This makes this era even more appropriate for the study of problem-solving, as real life demands holistic approaches from the solver when overcoming an unfamiliar situation (Meyer & Scholl, 2009; Robertson, 2016; Awasthi & Mohanty, 2021; Guo et al., 2023).

Choosing the University of Surrey in the United Kingdom (UK) for the research stay abroad was not arbitrary: Lewis Carroll spent some time in Guildford, the city where this higher institution is located, and both the Magdalen College and the Bodleian library in Oxford and Bletchley Park in Milton Keynes were close by so that in-person research could be carried out for the case studies. Even a statue of *Alice through the Looking Glass* (1871) can be seen in the Castle Grounds in Guildford, and an Alan Turing statue stands in front of the Austin Pierce building on campus. Additionally, supervisor and Head of the School of Literature and Languages at the time of this thesis Dr. Patricia Pulham was an expert in the Victorian era, which made her guidance convenient for the

project. Lastly, the excellent academic position that the University holds within the country and its broad resources could elevate the content of this thesis.

1.1. Objectives

- To overview how problem-solving has been present throughout time, be it in the form of ciphers, puzzles, riddles or any other type of enigma
- To understand the need to acquire problem-solving skills, both for external purposes and for its positive neurological effects
- To analyse and understand case studies as examples of the pivotal role of literary enigmas in the Victorian and post-Victorian era within a wider literary context
- To connect both theory and practice so that previous knowledge can be applied to future real-life situations
- To raise awareness about a Global Citizenship for the 17 Sustainable Development Goals (SDGs) by encouraging the development of these skills as a potential tool to mitigate the effects of climate change

1.2. Hypothesis

Problem-solving has been studied previously, but rarely from a literary approach, let alone with a Global Citizenship in mind as the ultimate goal. This thesis aims at addressing this gap in hopes that it might raise awareness of the need to have tools for a worldwide crisis. Therefore, the hypothesis is that the enhancement of problem-solving helps to manage personal and professional situations but can also be used to solve major conflicts, which is essential for the SDGs. Though this could be tested and verified through many means, the focus is on the interdisciplinary study of the relationship between British Literature and problem-solving, and how this can be applied to real-life situations.

2. Problem-Solving in the History of British Literature

Approaching British literature from medieval times until the 21st century provides a comprehensive outlook of how different types of problem-solving skills are present throughout time; whether in folklore, puzzles, ciphers, or anything involved with trying to find an answer to the unknown. Though this overview could have been divided into sections according to various methods and this is not necessarily the best one in every scenario, chronological order has been thought to be the optimal one for this research. Due to its extent and complexity, the exact order in which events occur makes it easier for the reader to grasp the cause and the consequences of those events better (Foreman et al., 2008; Hoodless, 2008). Therefore, the outline for the first section of the theoretical framework goes as follows: the Middle Ages, the Renaissance, Victorian times and war conflicts and the contemporary world, in hopes that moving in the direction of time rightfully depicts the evolution of problem-solving in British literature in the past and its relation to the present.

2.1. Medieval folklore: the beginning of problem-solving

Long before written records existed, stories survived by word of mouth (Bushaway, 2013). Whether it was in deeply religious villages or in faith-forgotten lands, the art of storytelling was a consolidated practice that guaranteed learning lessons or being warned about potential hazards. Like folk songs, riddles, legends, fables and fairy tales were passed on to younger generations, whose role in keeping and producing oral traditions for the next one was pivotal (Varner, 2007; Fulton, 2009; Cheeseman & Hart, 2022). Ordinary people were not taught to read nor write, and the print remained a point in the far-off future, which left oral folk tales as the only means to preserve the ideas and values of a specific community.

Not only did folklore, as a historical process of transmitting knowledge, contribute to the cultural growth of the British population, but it also ensured that neither customs nor beliefs eventually got lost in time. Some fictional folktales lacked the traditional taut structure and proved to be more casual and conversational. Hence, Swedish scholar Carl von Sydow coined the term “memorate” to describe a narrative from memory that

portrayed a personal experience which usually became the precursor of a legend (Dorson, 1999). Others did follow a specific scheme: the old wives' tales being at so early a date one of the many ways of oral folklore as well as ancient gossip (Walsham, 2013). Because they were a form of traditional wisdom, their veracity was unquestioned, and their consequences were not a matter to be treated lightly.

The figure of the old widow that went to the stone every day and predicted a lucky strike or adversity, otherwise unbeknownst to others, was part of the medieval imaginary, but somewhat varied from town to town. Housewives from Yorkshire ascribed a bread dough that did not rise properly to the existence of a corpse in the vicinity and used to believe that the Devil would fly over the house should they cut off both ends of the loaf. In Dorset, a slow-boiling kettle might have been bewitched and accommodated a toad, as it was common knowledge that "a watched pot never boils" (Castelow, 2015). This saying's meaning changed in modern times and now, although marked as old-fashioned, is said to "mean that if you wait and watch anxiously to see something happen, it will seem to take a very long time, or it will not happen at all" (*Collins Dictionary*, n.d.).

Foreseeing death or welcoming a brief sojourn of those who had passed away was not infrequent within folktales, which usually involved the incorporation of supernatural creatures such as ghosts, magicians, or fairies. While white magic became a Christian symbol and focused on the benefits of certain plants to heal the ill (Loomis, 1948), black magic had associations with satanic worship and witchcraft. Some were especially prone to be pointed out as witches, such as unmarried women or midwives, since they could aid and "control" pregnancy (Anderson & Gordon, 1978). If their innocence was in question, these medieval superstitions sometimes had fatal consequences: at the slightest hint of suspicion, they were burning all the witches even if they were not one as evidenced by the significant number of accusations at the time (Ewen, 2011). Thus, folk tales helped to scare children and adults, but were also intended to prevent tragedies from happening.

Oral cultures were by their very nature highly kaleidoscopic. The tangible diversity which made up Scotland, Wales and England meant that "each

supported their own quite particular vernacular repertoires which served to divide up all three countries into a series of palpably distinct cultural environments” (Fox & Woolf, 2002: p. 13). In other words, oral folklore also accommodated the minds of the inhabitants of the distinct regions within Britain and created boundaries that would differentiate their development later on. While some may have found common ground within their experiences due to proximity, cultural components such as charms associated with luck, ceremonies and rituals or the omens portending fatal auguries were often mismatched since they stemmed from miscellaneous sources.

The spoken word was crucial to fashioning the mental world of the vastly illiterate population, and later proved to be a stimulus to local folklore and the establishment of their very own cultural history (Bushaway, 2013). These traditions were not only limited to the relationship between life and death: people also found themselves grieving for the living, depending on the beliefs that they subscribed to. While according to Christian convictions, the soul was released to another world, pagan burials were grounded on the widespread ancient European belief that the soul was not annihilated, but rather “in association with the body, in a way that remains a mystery, it journeys to a new home in a land unknown to the living” (Niles, 1991: p. 133). Folk tales did also address various potential outcomes once life was over and held people responsible for their actions while walking on Earth.

It is not entirely surprising then that traditional tales used to hinge on ethical or moral dilemmas, or that they allowed insight into the way people thought. They encouraged keeping one’s promises, but strongly advised against making rash ones; the wicked were not successful, but rather integrity and courage were rewarded at the end (Olson, 2019). A heroic tale could set an example of model behaviour, but the quick-wittedness and resourceful characters such as an impoverished person or a young child could also solve the problem that the story got entangled with, even if they did not stand a privileged position within society. In that regard, the recipients of the story had both someone to look up to and someone that they could relate to: this shows why traditional storytelling, along with its collection and further study, reached such a distinguished

position in the broader context of literary debate (Goodchild et al., 2017). The mutual influence between a well-established corpus of myths and legends and the borrowing and re-performing of individuals was of paramount importance, along with an exponentially complex dynamic “between the performative, contextual nature of an oral narrative and its written, textual, scholarly formalisation” (Carrassi, 2017: p. 34). Folklore provided a heritage that needed to be protected and conserved while leaving room for historical and cultural exchanges.

Eventually, folklore paved the way for a more reliable way of recording stories. The earliest written records of the English language firstly emerged from a set of Anglo-Frisian or Ingaevonic dialects and would be later designated as Old English (OE) from 449 until 1150, which essentially referred to those texts composed before the Norman Conquest. Shortly after, French achieved a status of prestige as a language “that reflected the political, economic and institutional dominance of the Norman elite” (Hahn, 1999: p. 65). OE was already spoken in Southern and Eastern Scotland as well as some regions of England in the early Middle Ages, but it was not until the mid-5th century that it was introduced to Britain by the Anglo-Saxon settlers. Therefore, there were no written records of OE prior to the interference of a handful of literate Anglo-Saxons (Gneuss, 1991). In the light of this scarce availability, Venerable Bede¹ became a prominent figure through his best-known work *Historia ecclesiastica gentis Anglorum*, or *Ecclesiastical History of the English People* (731), which, as the name suggests, gathered information about the Christian Churches in England and became crucial for the development of the nation’s identity.

Illiteracy was not only a low-class concern, since even most priests were uneducated. Notwithstanding the ambitious design that Alfred the Great²

1. Venerable Bede (ca. 673–735), also known as Saint Bede, was an English monk and scholar that established a dynamic exchange between tradition and innovation in his writings. His works include *Ecclesiastical History of the English People* (731) and other exegetical texts (DeGregorio, 2006).

2. Alfred the Great (848–899) was known as king of the West Saxons from his accession in 871 to his death in 899, but became later nicknamed as king of the Anglo-Saxons in certain quarters in the 880s. Among many measures, his programme included the revival

proposed to educate the sons of wealthy freemen, the ability to read and write was not commonly acquired in lay society. Consequently, it is assumed that Anglo-Saxon verse up to the time of the Norman Conquest (1066–1071) “was composed without benefit of letters” (Burrow, 2008: p. 2). Such oral folklore would have been “highly traditional in character, employing set patterns of expression (‘formulae’) adapted to the demands of the ancient alliterative metre” (Burrow, 2008: p. 2), the features of which blended in perfectly with the society at the time. The chances of an oral composition of these works were close to none, but authors usually sketched their ideas in their heads before writing them down. For an Anglo-Saxon author implied drawing upon the traditional alliterative verse. Poetry was, after all, another tool to represent the conditions, concerns, and aspirations of the population, which sparked a sense of kinship with their fellow neighbours.

There were four prominent dialects at that time from which literary problem-solving could develop: Northumbrian, an early medieval kingdom located in Northern England and South-East Scotland; Mercian, which was spoken in the Midlands and, along with the previous regions, was invaded by Vikings in the 9th century; Kentish, which now forms the counties of Kent, Surrey, Southern Hampshire and the Isle of Wight; and West Saxon, which belonged to the kingdom of Wessex and remained as the one employed for most of the best-known literature from this time (Shay, 2007). Far from falling behind on oral folklore, Welsh culture was also blooming and became the birthplace for one of the most renowned myths of British history: the Arthurian legend.

Contrary to popular belief, the stories about Arthur and his court had already been popular in the region of Wales before the 11th century. It was not until the release of Geoffrey of Monmouth’s *De gestis Britonum* (1135–1138) that European fame came through and other characters like Merlin or the concept of the Knights of the Round table were incorporated³ (*Britannica*, 2022), filling out certain gaps regarding his

of religion, learning and literacy (Keynes, 2015).

3. Geoffrey of Monmouth (ca. 1095–c. 1155) was a Welsh cleric who wrote both verse and prose. His most popular work *De gestis Britonum* was since recently known as *Historia*

knightly fellowship. That being said, scholars do not agree to consider him to be a historical figure. The first extant records of his heroic deeds date to 300 years after he was said to have lived, as found in the *Annales Cambriae*, a miscellaneous set of Latin chronicles presumably compiled in the mid-10th-century, and the *Historia Brittonum* (ca. 828 CE), a historical and topographical collection of information that included a depiction of the inhabitants and invasions of Britain.

Even though romanticising this era as one of knights in shining armour and enjoyable agrarian lifestyles is tempting, these were tough times, and the written word echoed the struggles of the citizens involved in a feudal system. Moreover, the landscape in Britain was massively covered by treacherous forests, and one could easily grow into an unsuspecting prey for the dangers that they entailed, including mistrustful tribes and unknown beasts (Hooke, 2011). The tribe that most altered British culture, however, were the group of people that today are commonly known as the Anglo-Saxons. Continental Saxons, whose origin was Germanic, used Old Saxon as the main language throughout North Germany. The *Heliand*, a metrical paraphrase of the Gospels dating from the 9th century, is the earliest extant document from this community (Lambdin & Lambdin, 2002), which marked the beginning of recorded literary OE history.

Little to no English prose can be stated with certainty to have been compiled prior to the late 9th century (Gneuss, 1991). The written evidence of verse is also strictly limited to a few glosses, two glossaries and a handful of lines of OE poetry as the only surviving literature from the 8th and 9th centuries. This lack of data is precisely what makes the knowledge of OE dialects as well as their highly adaptive usage and ever-growing scope incomplete or severely fragmented (Suárez-Gómez, 2009). Despite such hindrance, some archival material from the early 11th century like the laws of Cnut, issued by King Cnut⁴ during his reign with

regum Britanniae, but Michael D. Reeve's textual study confirmed the latter as the title that was used in earlier manuscripts (Smith, 2020).

4. King Cnut (ca. 990–1035) was the king of England between 1016 and 1035. The royal law codes that were passed during this time, drafted by Archbishop Wulfstan of York, were the last ones issued in the Anglo-Saxon period, hence their exhaustive study after the

the advice of his counsellors—making it the longest Anglo-Saxon law code—did indeed contribute to the documentation of this period, its non-literary nature notwithstanding. Not only did the manuscript contain an assemblage of laws from the Anglo-Saxon kingdoms, but it also stood its ground in the face of heathenry “as the practice of witchcraft, divination or idolatry” (*British Library*, 2022a). These statements offer a glimpse of the values of the Anglo-Saxons when encountering mystery, which were also reflected in their literary production.

The documentation of oral poems started with Cædmon’s famous *Hymn*, which was written during the second half of the 7th century (probably between 650 and 680).⁵ Although all the poems got lost, the Venerable Bede mentioned this one in the aforementioned *Historia ecclesiastica gentis Anglorum*. He attributed the piece to a supposedly illiterate cowherder, who, according to him, was “one of the greatest poets of his age” (*British Library*, 2022c). While the original text was composed in Whitby, which is now the county of North Yorkshire but used to belong to the OE kingdom of Northumbria, it was reproduced at least four times in the decades following his initial creation. As usually not more than one copy of each OE poem made it to the Early Modern Period (1492–1789), let alone the contemporary era, the persistent copying of the *Hymn* “indicates its literary and cultural value” (McCully, 2014: p. 24). Since it is the earliest extant poem on a religious subject in the history of the English language, it was clearly held to be significant by Cædmon’s contemporaries and enjoyed increasing popularity both then and now.

The *Hymn* might be the first surviving written evidence of OE, but there was already a rich literary—and more specifically, lyric—tradition that preceded this piece. Pagans were well-known for their extensive repertoire of riddles, charms or inscriptions and their subsequent recitation (Olson, 2019). These oral traditions were just as influential as the printed word, if not more, in the shaping of the people’s opinion, be it collectively

Norman Conquest (Ryan, 2013).

5. The only work which can be attributed to Cædmon (ca. 657–684) is *Hymn of Creation*, quoted by Bede, who thought that he had the power of song. He is said to have entered the monastery of Streaneshalch somewhere between 658 and 680 (Drabble, 2007).

or individually. Additionally, scribes were of great importance, as “the handwritten pasquillade could, under local conditions, work as effectively as the printed broadsheet to focus views and precipitate political action” (d’Avray, 2004: p. 68). Since members of the clergy such as monks, bishops and chaplains were responsible for a large part of surviving Anglo-Saxon prose from the 9th, 10th and 11th centuries, the sermon played a crucial role in their compositions, which were key for arousing evangelical fervour (Wenzel, 2022). In this sense, this segment of the population made it impossible for the manuscripts to accurately represent the needs and concerns of the social and cultural milieu, something that adds to the severe limitations of the study of OE.

OE poetry’s survival relies almost entirely upon four manuscripts: the *Beowulf* manuscript (early 6th century), the *Junius Manuscript* (10th century), the *Vercelli Book* (late 10th century) and the *Exeter book*. Interestingly enough, the latter was initially believed to have been written by Cædmon in the first half of the 11th century, but scholars acknowledged that multiple authors were involved in its making years later (Plecháč et al., 2021). In the *Junius Manuscript*, the poems remained untitled as usual, but they have been named “Genesis”, “Exodus”, “Daniel” and “Christ and Satan” by modern editors since they referred to biblical themes (*British Library*, 2022b). The *Vercelli Book* contains a compilation of religious texts, one of which is the earliest dream poem. Some of the lines of “The Dream of the Rood” were originally found as mysterious runic inscriptions in fragmentary form in the 8th century on the Ruthwell Cross in Dumfriesshire. These carvings served as a way of gatekeeping information from unwelcomed readers—yet another type of secret communication that required problem-solving—, a technique that the poet Cynewulf⁶ applied in both the poems that are preserved in the codex, “The Fates of the Apostles” and “Elene” (Bitterli, 2009).

As thoroughly studied as the *Beowulf* manuscript is, there is not much scholarly consensus about basic facts, especially regarding the date, means

6. Although not much is known about Cynewulf, he is one of the few OE authors whose name is known, four of his poems being preserved in late 10th-century manuscripts (*Britannica*, 2007).

of composition and the authorship (Donogue, 2004), but it is speculated that it might have been written by either two scribes or a single cleric. Despite being considered a great alliterative poem, Anglo-Saxon poetry did not follow the conventional poetic forms of modern English poetry and there was neither a strict number of syllables nor rhyme. The poem is set in a North Germanic world prior to the arrival of Christianity: hence, the religious and pagan references—especially Germanic folk traditions and popular belief—coexist within its 3812 lines.

Now housed in the British Library, this heroic tale is preserved in a single 11th-century manuscript which in the 16th century was rebound in a book bearing the designation *Cotton Vitellius A.XV*. Also requiring problem-solving, the Roman numerals alluded to the position that the volume of which *Beowulf* became part occupied in the famous library of Sir Robert Bruce Cotton:⁷ following this reference, the poem was the 15th to be found “on the first shelf of a bookcase that was topped by a bust of the Roman Emperor Vitellius” (Symes, 2007: p. 8). Among many features, it contained numerous compound metaphors known as “kennings” as well as runic inscriptions. Some of these include the three erratic ȝ-runes for *epel*, “homeland” in *Beowulf*, drawn by the first copyist of the codex (Bitterli, 2009: p. 5). They are not limited to this manuscript, for these abbreviations also appeared in the six runic riddles in *The Exeter Book*. For instance, “The Ruin”, where *ᚱ* is short for “man”, *ᚱ* means “oak tree” and *mod ȝ* stands for “modwynn”, “heart’s joy”, in Riddle 91.

The fact that riddles are enshrined in one of the only four surviving documents from this era shows how central they were to the understanding of British folklore. In Greek literature, two major collections have survived: *Book X of the Deipnosophistae* (*The Philosophers’ Dinner*, c. 228 CE) 5 by Athenaeus⁸— offering a large representation of riddles

7. Sir Robert Bruce Cotton (1570/71–1631) was an English antiquarian who became the founder of the Cottonian Library, his collection eventually forming the basis of the manuscript collection of the British Museum (*Britannica*, 2023d).

8. Athaneus (170–223 CE) was a Greek rhetorician and grammarian. His most notable work was *Deipnosophistae*, where nearly 800 writers from the ancient Greco-Roman world are quoted (*Britannica*, 2011).

by different authors— and *Book XIV of the Greek Anthology*. The latter contains a section devoted to arithmetical puzzles, oracles, epigrams, and riddles, a well-known example being the Sphinx’s enigma on man (Salvador-Bello, 2015). Along with the *Exeter Book of Riddles*, they embody the integration of riddles within society at the time.

The Exeter Book of Riddles is an anthology of religious and secular poetry in OE, which was written in the South of England towards the end of the 10th century (ca. 960–980) in the conventional alliterative style of OE verse. There is no consensus on whether it was copied by one or more scribes, but it is the largest compilation of OE poetry, with almost 100 riddles, gnomic verses and several saints’ lives as well a body of elegiac verse inserted in three uneven batches (Salvador-Bello, 2015). Several pages are missing towards the beginning and the end of the codex (Bitterli, 2009), which may account for why no solutions to the puzzles nor clarifications are stated within the manuscript. In all other cases where runic clues are employed, they were a means of encoding information or encrypting solutions. They encoded the sign of the poet Cynewulf in the two longest poems, “Christ II (fol. 32a)” and “Juliana (fol. 76a)”, in the same way as he already had done in the *Vercelli Book*.

Both mysterious puzzles and moving elegies are the primary parts within *The Exeter Book*. The text delved into the themes of mourning loved ones, the passage of time and the inevitability of death, the feelings of profound desolation and sorrow that came as a consequence of loss. Sensitive topics such as the alienation of exile, including the ultimate ruination of one’s past, left no stone unturned (Murphy, 2011). These pieces participated in the indigenous tradition of vernacular poetry: lovers that were forced to separate, long-gone wanderers or lonely seafarers are common characters in the elegies, e.g. “The Wanderer” and “The Seafarer”, which depicted the Anglo-Saxon wisdom literature that has been found scattered throughout the traditional genre categories. The most weight in this collection, however, is given to the riddles and metrical charms.

In the 9th century and the 10th century, the usage of cryptographic writing

and logographs can also be found within the Carolingian *Lorsch Riddles* and the didactical writings of Alcuin of York⁹ and in the *Reichenau Riddles* and the *Jocoseria* of pseudo-Bede,¹⁰ respectively (Bitterli, 2009; Salvador-Bello, 2015). Similar illuminating parallels to both the Anglo-Latin and the OE verse around the late 8th or early 9th century are identifiable in both *Disputatio Pippini cum Albino*, a riddle-dialogue explicitly composed for one of Charlemagne's sons, and *Propositiones ad acuendos iuvenes*, a set of mathematical problems, where Alcuin "deploys the same literary strategies that characterise the more elaborate verse riddles of his compatriots" (Bitterli, 2009: p. 4). The second revival in the 10th and 11th century is evidenced by the survival of riddle collections within continental manuscripts, handwritten documents produced in Europe, that "betray in some way or another a connection with Anglo-Saxon England" (Salvador-Bello, 2015: p. 42). These texts are, therefore, fundamental to the understanding of the original manuscript and its powerful contribution to the development of the genre.

OE Riddles displayed the same interest for numerous structures and themes as Latin collections, but they also shared the scholastic passion for natural history, etymology, and wordplay. Precisely due to of the domination of the Latin models, these literary works emerged from an intellectual circle of monastic origin that could access a cultural formation rather than from a social vacuum (Orchard, 2005). Riddle 1 in the *Exeter Book of Riddles*, for instance, the answer of which is a storm as a reference to the Biblical Flood, embodies the complex dynamic of this type of literature, which suggests "the dualism and reconciliation of opposites that characterises OE wisdom literature" (Lambdin & Lambdin, 2002: p. 30). A line was drawn between the written word, which prognosticated the upcoming literary development for a few, and the oral tradition of the people, which was kept alive due to the influence of superstitions. Dreams and even fertility rituals, especially run by elderly villagers, were

9. Alcuin of York (ca. 735–804) was a disciple of Venerable Bede and became later invited by Charlemagne—the first emperor to the Romans between 800 and 814—to the court as something of an education czar (Willinsky & Provençal, 2013).

10. Pseudo-Bede refers to writing that are falsely attributed or imitate the style of Bede.

still leading beliefs that were not easily overran by the fresh methods of recording stories. In spite of the decisive presence of Scandinavian communities after the 10th century in Britain, their traditions remained undocumented due to their orality (Hahn, 1999). Folklore survived every attempt—and sometimes success—of modernisation of literature, even when a disintegration of the old standard written language eventually occurred.

This collapse should not be grasped as the end mark of all Anglo-Saxon literary traditions. OE production is considered to end around the 12th century, where Middle English (ME), the English dialect employed in roughly the same area from around 1100 to about 1500, begins. The change from one to another was, of course, of gradual nature: the OE traditions did not disappear overnight, but rather ME was a progressive transformation that was unhurriedly integrated and coexisted with the former (Schendl & Wright, 2011). In fact, the few documents of the late OE period withstood the test of time well enough throughout the entire period that ME encompassed. Some of the Anglo-Saxon prose authors, especially Ælfric¹¹ (ca. 950–1010), showed concern about the unreliability of scribes while copying a manuscript, as he did not wish to be blamed for any mistakes, and subscribed himself to the importance of correction (Treharne & Walker, 2010).

Even religious recluses, who lived in a more isolated position than the average, fell within the ambit of OE, which said much about the extent to which it was influential. As for poetry, the Anglo-Saxon alliteration still lived vicariously through *Layamon's Brut* or *The Chronicle of Britain* (ca. 1190–1215), a 16,096-verse historical record of the kingdoms of Britain (Allen et al., 2013). Anglo-Saxon customs did survive, but yielded up the central place that they occupied in 1000 to the new dialect. If OE were on fire, ME was made of ashes too: the latter started to become more socially accepted, whereas the former was no longer the norm and now belonged more to the marches than to the capital. During the 12th century,

11. Ælfric of Eynsham (ca. 955–ca. 1010) was an English abbot who often presented his work as being for specific people, or for those who knew little to no Latin, such as young boys (Gittos, 2014).

the native literary culture had already experienced a recession that became visible in the linguistic changes associated with the disintegration of the old written standard (Gneuss, 1991). This withdrawal led to an adjustment of the English language and determined its evolution in the next centuries.

Many of the texts that were generated during this period remained anonymous, a common characteristic of the Middle Ages. As opposed to contemporary understandings of authorship, which sometimes work around the notion of the Romantic concept of “the artist” or are nowadays heavily influenced by modern copyright laws, property rights and the condemnation of plagiarism over a text, authorship in the Middle Ages was perceived as quite the contrary (Minnis, 2011). Instead of holding someone accountable for the compliance with property rights, the contribution to enriching and expanding one’s culture was more likely understood as an intellectually and morally authoritative tradition. There were no fixed categories of “writer”, “copist” or “translator”, as the engagement in several roles depending on one’s abilities was not only allowed but also encouraged. This way, the literary reproduction and spreading of information became an easier and more effective task for everyone.

This firm belief did not always stand on steady ground, as eventually a palpable tension between the traditional nature of “OE poetic composition (in which—in the oral tradition at least—authors may be seen and heard and thus go unnamed within their texts) and the authorising effect of naming in relation to authorship in the Latin tradition” (Bredehoft, 2009: p. 19) grew in the literary world. This change in the dynamic of the relationship implied a greater distance between the author and the audience and required for the first to appeal to the attention of the second. This latter had to recognise themselves as the receiving end and somewhat unbiased recipient to also achieve the desired distance between text and self. The act of reading was no longer understood as just the vocalisation in public of a text for mass entertainment, but also as a meaning-making activity that demanded for the reader to be engaged in the process to achieve a sensitive and meditated interpretation of the story (Coleman,

2005). The gradual introduction of more titles made the establishment of further categories necessary, some of them again drawing from popular folklore.

Stories that had only seen the light of day through oral transmission had now the opportunity of being transcribed into actual texts. The range of supernatural creatures was not only limited to the heroes and dragons in *Beowulf* and the chivalric themes that predominated literary production such as in *Sir Gawain and the Green Knight* (late 14th century), but there was also room for fairy mythology and magic beyond soldiers. A fairytale was a traditional story the form of which had been handed down by oral transmission from the past: its content did not necessarily involve fairies as the main characters of the narration, but about “fae’ry, fe’erie, fays’ work, or enchantment” (Collingwood, 2005: p. 115). In other words, elements arising out of the idea of magic were present and played a relevant role in the course of events.

It was poetry, however, the genre that stuck to the central literary position in the Middle Ages for a very long time (Lambdin & Lambdin, 2002; Dalrymple, 2008; Treharne & Walker, 2010). Thus, it was deemed to be the highest form of discourse, John Gower and Geoffrey Chaucer belonging to the first generation of English personalities who would become recognisable writers.¹² French, Latin and English were the preferable languages that Gower employed in his three major works, *Mirour de l’Omme*, or *Speculum Hominis* (ca.1376–1379), *Vox Clamantis* (ca.1377–1381) and *Confessio Amantis* (ca.1386–1393), respectively. Moral allegory and courtly love were a common thread throughout his works, which at that time matched his contemporary Chaucer.

Running to over 17,000 lines within 24 stories, Chaucer’s *Canterbury Tales* (1387-1400) was written in a London dialect of what is referred to as ME. Most of the tales are written in verse, though some in prose. The framing device for the set of stories is a storytelling contest that 30

12. John Gower (ca. 1330–ca. 1408) was an English poet who is thought to be of Kentish origin (*Britannica*, 2023b).

Geoffrey Chaucer (ca. 1340–1400) was an English author, undertaking many jobs throughout his life, but recognised the most for his literary works (Pugh, 2013).

pilgrims took part in as part of their outbound journey to the shrine of Thomas Becket in Canterbury, Kent (Pugh, 2013). Having this journey as an excuse allowed Chaucer to gather together people from utterly disparate backgrounds, the presence of which in the same room would have been difficult to justify otherwise. It also enabled the combination of multiple genres including “legend, courtly romance, racy fabliau, saint’s life, allegorical tale, beast fable, medieval sermon, [or] alchemical account” (*Britannica*, 2020). Due to the lively nature of the tales, much has been speculated about the missing return journey—an unsolved enigma to this day. Due to Chaucer’s mathematician formation which added to a learned treatise on the astrolabe, his tales have often been studied from a problem-solving perspective. For instance, *The Canterbury Puzzles, and Other Curious Problems*, released in 1907 by the English puzzlist H. E. Dudeney, was a collection of riddles based on the characters’ personal experiences (Newing, 1994).¹³

Figure 1

The Wife of Bath’s Riddles (1907)



According to Dudeney, whose reputation preceded him as a critically acclaimed mathematician and puzzle creator, while some “knowledge of mathematics and a certain familiarity with the methods of logic are often of great service in the solution of these things, yet it sometimes happens that a kind of natural cunning and sagacity is of considerable value” (Dudeney, 2008 [1907]: p. 12). A well-made puzzle should expect the

13. Henry Ernest Dudeney (1857–1930) was a British author and mathematician whose large literary production is focused on logic puzzles (Newing, 1994).

reader to use their wit and ingenuity, so a better education was not always an advantage as a stimulated imagination and good reasoning skills were. The following extract is from “The Wife of Bath’s Riddles” (Figure 1 on the previous page), the 5th out of the over 100 riddles that are included in the collection (Dudeney, 2008 [1907]):

The frolicsome Wife of Bath, when called upon to favour the company, protested that she had no aptitude for such things, but that her fourth husband had had a liking for them, and she remembered one of his riddles that might be new to her fellow pilgrims: ‘Why is a bung that hath been made fast in a barrel like unto another bung that is just falling out of a barrel?’ As the company promptly answered this easy conundrum, the lady went on to say that when she was one day seated sewing in her private chamber her son entered. ‘Upon receiving,’ saith she, ‘the parental command, ‘DEPART, MY SON, AND DO NOT DISTURB ME!’ HE DID REPLY, ‘I AM, of a truth, thy son; but thou art not my mother, and until thou hast shown me how this may be I shall not go forth.’‘ This perplexed the company a good deal, but it is not likely to give the reader much difficulty (p. 28).

This short excerpt contains two riddles, the first one being “Why is a bung that hath been made fast in a barrel like unto another bung that is just falling out of a barrel?”, the answer of which is stated on page 166. When paying attention to the position of the bung in relation to the barrel, one finds that a bung that is made fast in a barrel is *in secure*, whereas the one that is falling out of a barrel is also *insecure*. The strategic wordplay is not used in the second puzzle, where there is a lack of information that might act as a dazzling haze for the reader to assume that the parental command came from the mother, when, in fact, it was the father’s order, who was also in the room.

The Canterbury Tales were precisely one of the first privileged texts that got to experience one of the most revolutionary inventions up to date: the printing press. Due to the enormous popularity that it attained, William

Caxton printed this collection along with other titles such as Gower's *Confession Amantis* (1390) and Sir Thomas Malory's *Le Morte d'Arthur* (1485), when the legend reached its apogee by providing the readers with "an encompassing view of a range of moral experience" (Sanders, 1994: p. 80).¹⁴ Before Caxton, who brought and set up the technology of printing to London for the first time in history around 1476, scribes were in charge of copying out books by hand. Except for historical records attesting the veracity of some events, the usage of written documentation as proof remained an unrealistic goal. The overwhelmingly high percentage of illiteracy and the limited resources had restrained the few educated people's possibilities. They now aimed at keeping the handful of manuscripts from previous times that were available and exponentially increasing the number of volumes through the printing press (Peacey, 2013).

Printing transformed the way that information was generated and how it circulated completely. The situation had already been changing, and the incorporation of this new machine was an absolute game changer (Peacey, 2013). The access to actual book copies was still very much restricted for most, though not as inaccessible as it was before. Carpenters, artisans, or tradesmen sometimes had the chance to read a story or a political pamphlet in-between long work shifts (Dalrymple, 2008). As much as the range of books in the later centuries branched off, literary prose prevailed as the specialised medium. A slow but steady pace marked the growth of the novel, which would turn into one of the major turning points in the history of literature and eventually enable the accommodation of virtually every kind of literary experience.

Storytelling by the fire, heroes flying around, and ghostly scenes still managed to stay between the people, who managed to pass folk tales and customs on despite having no means to record them properly.

14. William Caxton (ca.1415–ca.1492) was a printer and translator who produced a wide variety of vernacular texts on classical subjects during the late 15th century (Day, 2022). Little is known about the identity behind *Le Morte d'Arthur*'s author, Sir Thomas Malory, other than his work was printed by Caxton and retells the adventures of the knights of the Round Table (*Britannica*, 2023f).

Folklore did not ever die, since it is very much present in popular culture nowadays such as the fantastic creatures in *The Lion, the Witch and the Wardrobe* by C.S. Lewis (1950), shadowhunters in *The Mortal Instruments* by Cassandra Clare (2007–2014) or the portrayal of witches in North American singer Taylor Swift’s imagery for the music video *Willow* (2020).

The phase of orality that undertook the early Medieval era resembled the growth of romance languages from Classical Latin, since more than 90% of the population did not speak French nor Latin. English functioned as a “descriptor of language, national identity and literary activity” (Hahn, 1999: p. 67), which was restricted to those that held holy positions. While the Medieval Era was still recovering from an unsteady yet intricate literary process, the world was about to take a turn: a series of favourable events during the last few centuries allowed the ideas of an Italian-born movement, the Renaissance (“rebirth”) to flourish within the British country (Spiller, 2004). In the late Middle Ages, literature replayed its footsteps on every stepping stone in an attempt to correct the written habits that had sealed their literary fate: these would drastically switch in the 16th century with the arrival of the Early Medieval Era.

2.2. (Un)solved riddles in the Renaissance: cultivating the search for answers

As a result of a sequence of historically crucial events, there was an influx of talent into Florence as well as other Northern Italian cities due to migrating Greek scholars after the fall of Constantinople in 1453. This migration resulted in the spreading of a renewed interest in Greek and Latin forms. Shortly after, the Wars of the Roses (1455–1485), vied between the houses of Lancaster and York for the English throne, led to the government of the Tudor dynasty (1485–1603) after a long series of violent animosity and civil strife (Grummitt, 2004). These armed conflicts were named later on as such after the supposed badges of the belligerent parties: the red rose of Lancaster and the white rose of York, reunited in the marriage of Henry VII to Elizabeth of York.

The Tudor period was marked by successor King Henry VIII,¹⁵ who managed to become head of the Church through the Act of Supremacy in 1534. Through the execution of this power move to break with the papacy in Rome, he could proceed with a legal divorce and remarry. At the beginning of the English Reformation (1527–1590), after an intense tug of war between the two forces, Henry VIII's strategy succeeded, and the Anglican church was founded by Elizabeth I¹⁶ in 1559 (Hollander, 2017). The Reformation became the defining event of the 16th century, as it weakened the authority figure that the Pope embodied and left its mark on shared spaces such as the ecclesiastical, political, and economic scene, but also on the private sphere (Newcombe, 1995). The Protestant Reformation coincided with the belated introduction of the printing press in Britain and fuelled its development.

Literary modernisations that originated from Italy—such as the Petrarchan sonnet, the *canzone*, blank verse, the pastoral of Jacopo Sannazzaro or the epic of Ludovico Ariosto—also made their way into the English language. Some traditions remained a part of the social milieu, even if they shapeshifted, and people participated in riddling exercises in all sorts of social situations under the Tudor dynasty, “from the fireside folk tales and witticism of the peasantry to quick-witted humour of the court” (Bryant, 1990: p. 32). A new tension emerged between the linguistic British traditions and the state-of-the-art values at the time that were integrated within these forms. Slowly yet steady, the decay of the Church and the feudal system culminated during the Early Modern Era. Repeatedly, scientific innovations such as the first spectacles of polished lenses, the printing press, and of course the Da Vinci's in the late 1400s¹⁷ played a decisive societal role (Bucolo et al., 2020).

The Bible was the first text to ever be printed by Johannes Gutenberg

15. Henry VIII (1491–1547) was King of England from 1509 to 1547 and became well-known for his radical changes to the Constitution (Ives, 2007).

16. Queen Elizabeth (1533–1603) reigned from 1558 until her death, this period later named “the Golden Age of England” due to the peace and stability that the country experienced during that time (Hollander, 2018).

17. Some of Leonardo Da Vinci's (1452–1519) inventions include the helical aerial screw, the anemometer, and the parachute (Bucolo et al., 2020).

and remains to this day as one of the few incunabula—which stands for any book, pamphlet, or broadside that was printed up to the year 1501 (*Britannica*, 2013)—from the early stages of printing in Europe (Chaplin et al., 2005). Due to the rise of literacy among the middle-classes, who requested a greater variety of books to choose from, the hand-copying method was no longer appropriate (Peacey, 2013). Promptly the need to accommodate the public's interests could not be delayed anymore. Not only would it encourage the exchange of ideas among intellectuals, but also facilitate the communication between the scientific community through scholarly journals. Printing was a high-priced business and the printing house as well as booksellers “needed to ensure that there was a viable market for the multiple copies the presses were producing that was not compromised by competition from other printers” (O’Callaghan, 2000: p. 86). Likewise, the literary property was closely linked to book trade rather than copyright in the way that it is associated with authorship today.

Such innovations slowly paved the way for modernisation in Britain. Belated in comparison with Germany and the rest of Western Europe in general, the ultimate religious authority in England (the Church) took issue with the newest print technology. The commercialisation of book production was unprecedented yet extremely advantageous for the spread of knowledge (Peacey, 2013). By that time, ME was already experiencing a linguistic reshaping and would eventually reach a mature form, Early Modern English (eModE), which began in 1500 (Nevalanien, 2006). However, there is no reliable evidence on how many people could read during the English Renaissance, so no conclusions can be drawn about mass literacy in that period.

The question of who should be educated met the resistance of some scholars, who feared social unrest should an overproduction of intellectuals occur. The widespread dissemination and massive production of texts therefore sometimes encountered the opposite effect, even if the printing press “would seem to fix ideas, to render them permanent and widely available” (Sullivan & Woodbridge, 2007: p. 265). Illiteracy was not a black-or-white matter anymore, and the progress that was made had

to consistently swerve bumps on the road.

Since writing and reading were taught separately, signing with a mark instead of a name was likely the result of an acute/chronic illness or the will to remain anonymous. Likewise, the assumption that over 90% of women were uneducated lacks reliable data as they were often under-represented in most statistics (Brink, 2000). These activities were perceived as “potentially dangerous activities for women, activities that without careful surveillance could lead to transgressive behavior” (Walker, 1996: p. 15), whereas such a power in men was praised. These double standards did not allow half of the population belonging to upper and middle-classes to be educated, or it was merely seen as an accessory for an aspiring wife. Having said that, notwithstanding the incomplete data, it is assumed that the literacy levels dramatically increased.

The adult literacy rate rose exponentially as a consequence of the easier access to libraries, which superseded the sole admission to the clergy. By gaining access to knowledge, the yearning for learning was not an unrealistic purpose anymore, although manuscripts were still limited to the elite (O’Callaghan, 2000). Some privileged erudite people could attempt to understand how the world operated and acquire decision-making and problem-solving skills, otherwise obscured by the incentivisation of religion. Education proliferated among middle and upper classes, including the setting up of state schools which were available for a limited number of people that could not afford private tutoring. Though still a long-term goal for the vast majority of people, the mid- and late 15th century experienced a notable increase of those who went beyond religious preaching. The distribution of scientific content left room for the exploration of new values in education (Moran Cruz, 2008). Even if illiteracy was still overwhelmingly present, literary evolution had taken its first steps towards a brighter tomorrow.

Secular education promoted the rise of professionalism based on freedom, and the individual human importance in the medical and legal fields as well as in government service. The acquisition of knowledge “promised control of society and the world, and rhetoric and eloquence were privileged as valuable tools of public life” (Walker: 1996: p.

2), which aided the profitable contribution of individuals to society. Self-determination and self-fulfilment in worldly matters rather than metaphysical ones were strengthened by the nonreligious ideals promulgated by humanism. Even though the term “humanism” was not coined until the European Renaissance, these early scholars definitely drew inspiration from the attitudes that they were introduced to through manuscripts from Ancient Greece (Grendler, 2006). After the Middle Ages began to shake the hitherto solid Christian ground, people needed to reinvent themselves as they realised that they had more questions than those the church could give answers to. The accentuation of the human realm, as well as the analysis of the world from a naturalistic perspective rather than a series of arbitrary actions from God, prevailed in the development of literature.

The Elizabethan era (1558–1603) succeeded such developments as England’s population doubled: horticultural systems and commercial veins were first tapped as the industry blossomed (Hollander, 2017). The agricultural prosperity mainly relied on sheep farmers, who pursued a pastoral boost that would later become the inspiration for traditional Elizabethan pastoral poetry. As a result of this rapid expansion, food prices rocketed, and rents quickly followed, wages hitting an all-time low (Richards, 2012). While old social loyalties dissolved and social relations were relegated to a state of fluidity, the profits of merchants and ambitious lesser gentlemen remained stable. At the expense of nobles and workers, the middle class got the upper hand in the commercialisation of products, including the literary industry that was undergoing its greatest momentum to date. This transformation was not a matter to be taken lightly, since it had unequivocal consequences in the chrysalis state that the English language was at.

Early Modern English represented the change from the old, tradition-soaked culture to the new mechanical civilisation (Nevalainen, 2006). Due to the consequences of the religious dissent that Britain was undergoing, the individual experience with God without the intervention of intermediaries persisted as opposed to the traditional guidance of priests. People’s own perception of themselves, their connection

with their faith and their interaction with the world began to shift, but eventually culminated in crisis, as such a situation was unprecedented (Richards, 2012). Society lacked an alternative system of values and therefore proceeded to build a brand-new structure that aligned with the scientific advancements while leaving room for a new relationship with religion. These adjustments also came naturally to other fields, language and literature being some of them. Medieval institutions were focused on the training of the clergy, and Renaissance universities intended to retain that focus at first too, but the breadth of their audience dilated throughout time.

While juxtaposing completely opposed experiences, tones, and worldviews, the Elizabethans possessed the ability to diverge their texts to suit different readers simultaneously. Their writing was complex as well as powerful and derived from classical literature for the most part (Hattaway, 2005). Believed to be crucial in human education, their literary resources never went out of style because they provided the readers with a humanistic and socially admissible way of writing with an Early Modern twist. Meeting certain requirements such as the approach to tradition as well as the balance between the old and the new determined the quality of a text. Cicero and Ovid were a safe bet when writing, as literary reproductions were an accepted source of inspiration rather than a lack of originality.

Interestingly enough, drawing upon ancient classical Greek and Roman arts was praised as opposed to creating new content in the 15th and 16th centuries (Grendler, 2006). Authors such as Horace and Virgil¹⁸ were repeatedly an inspiration in the Renaissance, partly because they were thought to provide the finest guides for learning and living. Through their texts, one could discern the importance of rules within society, but also value the individual worth that each person possessed (Grudin, 2022). This self-recognition proved to be central for the integration of literature

18. Cicero (106 BCE–43BCE), Ovid (43 BCE–17/18 CE) Horace (65 BCE–8BCE) and Virgil (70 BCE–19 BCE) are all canonical Western writers from classical Latin literature. Their contributions shaped the Renaissance and continue to being subjects of study nowadays (Habinek, 1998).

into one's identity. Within this period, it was established that literature, and more specifically poetry, should teach religious and/or moral lessons, so that it had a set purpose that writers had to stick to. The idea that readers would benefit from a dual literary function also started to emerge as the coexistence of education and delight—both entrusted on the same level— was greatly influenced by humanism.

Though Renaissance, humanists borrowed a few resources from classical texts, many others were still medieval¹⁹ and they coincided with the ever-growing presence of humanists' ethical preoccupations regarding human concerns besides spirituality (Grudin, 2022). Humanists' interests in people as individuals set them apart from medieval philosophers, whose line of thought was fundamentally focused on religious matters, but also sought a point of convergence between national and local lore and the incorporation of new elements. By doing so, the intellectuals went beyond the limited scope of Christian theology that characterised medieval learning and invested themselves in updated literary resources.

Philip Sidney's *Defence of Poesy* (1595) was the embodiment of this change, his work being considered one of the earliest examples of English literary criticism.²⁰ He depicted the world as it ought to be and enhanced the parts that needed to be revised and corrected as opposed to leaving events to a capricious fate. Albeit idealistic, the unsolved external and internal conflicts in his poems, such as the desire against restraint and heroism over patience were recurrent themes and the inspiration for new forms and melodies (Siobhan, 2008). These which reflected his political ideals and support towards foreign policies. The sonnet sequences were also attributed to his work in *Astrophel and Stella* (1591), which debuted as the first extended poetic treatment of a single theme, making him a pioneer in his field. Sidney was an assured innovator whose potential would be pivotal for both his generation and upcoming literary movements and subscribed to the idea of reproducing

19. It would have been rather unrealistic to expect a radical transformation overnight with no influence from the values and on-going themes from the past few centuries.

20. Philip Sidney (1554–1586) was an English poet and became one of the most prominent figures of the Elizabethan era (Stillman, 2008).

an updated version of canonical works. He also joined the riddle tradition in the Second Eclogues in *The Countess of Pembroke's Arcadia* (*The Old Arcadia*) (1593), where the crowd speculates on what the two following riddles might mean (Sidney, 1999 [1593]):

Nico. Tell me (and be my Pan) the monster's name
That hath four legs, and with only two goes;
That hath four eyes, and only two can frame.
Pas. Tell this (and Phoebus be): what monster grows
With so strong lives that body cannot rest
In ease until that body life forgoes? (p. 128).

Some scholars have attempted to solve this riddle, often unsure about whether the answer to both enigmas was the same one or not. While William Ringler suggested “a man on crutches wearing spectacles” for the first one but gave up on the second, Wendy Gibson pointed out that the solution should indeed be the same since Nico and Pas had been “matching each other verse for verse” (Gibson, 2009 [1977]: p. 520). Instead, she proposed “a pregnant woman”, since the verses resembled such arduous state and it corresponded with the connotations that childbearing had at the time, which was a natural consequence—and even a reward—of pastoral love. Naming someone's offspring “a monster” is a singular approach though, so some have alluded to sexual intercourse as the solution since it was an indelicate but common theme in singing contests between the common folk (Considine, 2003).

This conversation is recalled in *The Holme Riddles*, a collection of over 140 enigmas compiled by three out of the four members of the Randle Home family from Chester (1570–1707), where they mentioned “four eyes clear of sight: 4 ears whereby to hear, & 2 bodies exceeding clear”, the answer of which was “an exchang[e] woman big with child” (Tupper, 1903: p. 237). While it seems to support Gibson's idea, the right answers of the original riddles were left unanswered for both the characters in the

story and the reader to guess on their own. All four successive Randle Holmes generations were herald painters and genealogists as well as collectors of legal and historical data and this anthology is essential for the scarce preservation of Cheshire history.

The riddle tradition continued to be fostered and cultivated in the Renaissance, another valuable collection being *The Riddles of Heraclitus and Democritus* (1598). Though the title alluded to the pre-Socratic philosopher, there was no connection between the book and the Greek thinker. Since Heraclitus was deemed to have been the arch-riddler of his time, the reference was justified and caught the attention of the audience by using a long-respected name. From domestic animals to ordinary objects, the myriad of themes assembled a sixty-piece anthology that varied in length, metre and subject (Bryant, 1990).

Riddles developed in all kinds of academic circles, and even composers “started to wrap their intentions in cryptic sentences” (Schiltz, 2015: p. 71), or make the audience second-guess their own interpretations. This wide appeal for linguistic puzzles had both a theoretical and practical grounding, as they were written to be put together into collections, but they were also the subject of study of literary scholars, who actively tried to document theoretical developments on the origin and social usages of riddles. The reflection of their evolution was imperative for the analysis and further understanding of social gatherings, which mirrored the humanist goals of accentuating the human realm. These meetings were organised in both upper and low-class spheres, and although the topics of such mysteries came from different backgrounds, they were appropriate for both courtly and folk entertainment. The lyrical language stimulated the production of creativity rather than the communication in straightforward English.

When defining a riddle, some scholars go back to the Latin definition of “a certain brain-game that is rewoven into teachings” (*ludus quidam ingenii in doctrina retextus est*) (Schiltz, 2015: p. 38), where the aspect of *ludus* acts as a didactic tool as opposed to a featherbrained element. Over the course of time, solving enigmas became a collective activity that quickly escalated due to the influence of the printing press, which

facilitated the production of books dedicated to games. There were different purposes that riddles could serve during the Renaissance: the question-and-answer format, for instance, was instrumentalised to illustrate and spread elementary religious doctrines. The courtly diversion also included this type of entertainment within their leisure activities. This style of recreation dovetailed nicely with the nobility's spare time, which consisted "not only of physical activities (such as hunting and dancing), board games (such as gambling and chess) and performances (of poetry and music), but also of conversations" (Schiltz, 2015: p. 38). Those cultural exchanges also encompassed existential questions and wordplay where a small group of people engaged in rule-based linguistic competition. These games required mental effort and contributed in an interactive way to the intellectual growth of the noble courtier.

These mental puzzles aided the camouflage of obscure matters, which were easier to communicate if they were introduced in a playful, non-harmful way. If not examined closely, dark wording could be misinterpreted or overlooked. Obscurity as a broad term meant that any type of message was not readily understood or clearly expressed: other obscure examples include sayings or proverbs, for instance (Mieder & Dundes, 1994). While in other contexts such a tool might not have been appreciated or even strongly discouraged, in this genre it was celebrated and even ritualised. These obscurities also served as a way of guaranteeing academic exclusivity of their teachings, similar to passing notes in secrecy. Limited to selected religious and intellectual groups, obscure linguistic devices protected these communities against the profanation of their knowledge. The gatekeeping of hidden mysteries induced the initiated to share learned matters solely with a modest circle of confidants.

This recycling and renovation mindset coexisted as writers generally tended to re-do what was already prevalent in literature but adapted it to their needs and concerns. For instance, Thomas Wyatt and Henry Howard translated "Rima 140" by Petrarch into English.²¹ All three versions were

21. Francesco Petrarca (anglicised as Petrarch) (1304–1374) was an Italian scholar and poet and one of the earliest humanist in the Renaissance. The translations by Thomas

transcribed almost word by word in the form of sonnets, as it had become the poetry scheme *par excellence* when it eventually arrived in England. The 14-line poetic form spread across Europe after Giacomo da Lentini's invention's success in Italy and the structure was essentially divided into two main parts at first: eight verses which introduced a conflict (ABBA ABBA) and six which attempted to solve it (CDE CDE or CDC CDC).²² Soon enough, British authors realised that the original metre was hard to apply to their poems, as the English language operated in different ways.

The Italian sonnet scheme could not be adapted into English due to the different priorities that were given to linguistic systems in each language. The English language based their metrical rules on whether a syllable was stressed or unstressed, while Romance languages were prone to focus on the length of syllables. The original Petrarchan sonnet experienced several modifications to compensate this problematic imbalance (Siobhan, 2008). Firstly, three quatrains and a closing heroic couplet replaced the octet and sestet division; secondly, the iambic pentameter was incorporated since it was a traditional element in metric in English poetry and verse drama, each verse consisting of 10 syllables and one in every two being stressed; lastly, the rhyme also underwent several changes even though the 14-line arrangement was preserved.

All these incorporations drifted away from the Italian structure and resulted in new types of sonnets (Siobhan, 2008), such as Edmund Spenser's Spenserian sonnet in *The Faerie Queene* (1590), or the Elizabethan sonnet, which eventually achieved the most stability.²³ Also named as the English or the Shakespearian sonnet, it was in fact not invented by William Shakespeare.²⁴ Petrarch's muse Laura was the

Wyatt (1503–1542) and Henry Howard (1517–1547) are often considered the sign of arrival of the English Renaissance (Guy-Bray, 2019).

22. Giacomo da Lentini was a Sicilian poet of the 13th century, traditionally credited with the invention of the sonnet (*Britannica*, 2018).

23. The poetic features of Edmund Spenser (1552–1599) involve a fusion of allegory and parody to capture the complex dynamic of the empire (McCabe, 2010).

24. Though his authorship has been questioned, William Shakespeare (ca. 1564–1616) is one of the most well-known Western writers, whose literary production includes *Romeo and Juliet* (1597), *Hamlet* (1599–1601) or *The Tempest* (1611).

addressee for countless verses on one-sided love, unlike Shakespeare's poems, which did not delve into the suffering of not being loved back; one specific person was usually the only subject of the poet's desire, whereas Shakespeare's had several addressees. That desperate love that was confessed in swooping, sloping letters had a specific place for the Renaissance writers, who bonded over being crestfallen at their unfortunate emotional attachments.

In spite of the mid-century reservations about the language's strengths and flaws, prose overtook poetry in the Elizabethan era in the sense that it was not only present in selected literary contexts, but also unconventional settings such as pamphlets or treatises that were easier to distribute. While it still did not hold a high literary status like poetry or drama, the general reaching of prose writing was uniformly high, and therefore revolutionised the transmission of knowledge (Hadfield, 2000). Since this information was not safeguarded by some, humanists often set themselves "against vulgar ignorance and folk tradition, but, fortunately, neither could remain aloof for long from the robustness of popular taste" (Cordner et al., 2023) as the participation of the folk in everyday activities was an open-shut case. In other words, the ordinary people's oral culture and traditions engendered their literary presence, be it wanted or unwanted by intellectuals.

Peasant backgrounds began to appear as more common in Europe, such as German intellectual Heinrich Bebel's, whose humble upbringings allowed his jests to be based on homespun German tales (Sullivan & Woodbridge, 2007), but whose university education made him spent time with fellow humanists like Erasmus.²⁵ Although the 15th century had provided some privileged male writers with an unassailable lead, obstacles abounded for women, regardless of the social position they held.

25. Heinrich Bebel (1472–1518) was a humanist poet born into a German peasant family and educated in Poland and Switzerland (Campbell, 2003).

Desiderius Erasmus (1466–1536), also known as Erasmus of Rotterdam, was a Dutch humanist and theologian (Campbell, 2003). He is considered an influential figure of the Renaissance due to his vast number of books, essays and translations, the well-known Erasmus+ exchange programme between EU universities named after him.

Women still struggled to achieve recognition even with the boost of the printing press due to their limited access to didactic resources. If writing as a skill was regarded with disfavour towards women, literary writing was even more controversial, the worst-case scenario being if publication was involved (Walker, 1996). One of the few successful and influential female personalities was Mary Sidney, Countess of Pembroke and Philip Sidney's sister (Goodrich, 2014). Other female writers include Elizabeth Cary or Aemilia Lanyer, whose work was the first substantial text to ever be designed by a woman that reached the printing stage.²⁶ Lanyer's volume *Salve Deus Rex Judaeorum* (translated as *Hail, God, King of the Jews*, 1611) has nine surviving copies, five of which are complete or nearly so. It was arguably the first protofeminist publication in England since all the dedicatees were women, and the female virtues were accentuated as opposed to the vices of men. Also the first female poet to ever assert herself as such, it was socially acceptable for middle-class writers who did not possess a fortune to seek patronage, an early step in the professionalisation of literature, and she was no exception (Woods, 1999). This economic support was intellectually incentivised by the perseverance to reflect on classical models and ideals: poetry was the epitome of the social reaffirmation of cultural values, the authors being the ones in charge to speak on behalf of the society they lived in.

Despite being prolific writers, much of their work was kept in its early stages (most likely in drafts or manuscripts), and limited to circulation among family, friends, or a close circle of intellectuals. For middle-class male writers, printing allowed a modest income and the possibility of climbing the social ladder, otherwise frowned upon within upper-class gentlemen. Aristocracy encouraged private literary exchange and

26. Like her brother, Mary Sidney Herbert (1561–1621) translated religious works into Latin, Italian and French, making her one of the first women to gain recognition for her literary production in England (Goodrich, 2014).

Elizabeth Cary (ca. 1585–1639) was a Renaissance historian, poet, playwright and translator, known for some notable works such as *The Tragedie of Mariam, Faire Queene of Jewry* (1613) (Wolfe, 2006).

Aemilia Lanyer (1569–1645), also known as Emilia Lanier (née Bassano), was one of the first female English poets to assert herself as such, attracting patronage and producing a large volume of literary production designed to be printed (Woods, 1999).

condemned the commodification of the publication of texts, which often depended on financial sponsorship (Wheale, 2013). Because men of lesser rank could achieve social advancement this way, the privileged could not chain those who were not to remain in lower social positions, since class mobility “depended on the display of learning, and publication, despite the stigma of print, offered a wider audience to the aspiring male writer” (Walker, 1996: p. 146). Based on humanist beliefs once again, the learning process and the acquisition of eloquence became essential skills for well-educated men, whose access to philosophical and classical studies enabled them to be perceived as scholarly individuals.

This opposition towards the strict and narrow-minded limits of religion and class enabled the exploration of obscure themes, such as witchcraft. *Malleus Maleficarum* (1486), often translated as the *Hammer of Witches*, decreed any “magic” was heresy and became the first treaty to specifically condemn such controversial practices (Broedel, 2003). It stated that female lust led to paper-thin pacts with the Devil, hence women were singled out for the most part. Midwives were particularly pointed at for their alleged ability to control and prevent conception and end pregnancies should they wish to. The main objective of the *Malleus Maleficarum* was to establish legal procedures which could lead to identify and exterminate witches, so that they were accused of atrocious activities such as eating infants or offering them as a sacrifice to the Devil.

No longer can texts about dark magic in the Early Modern Period be relegated by intellectuals as a mere superstition or blissful ignorance. In 1566, the earliest English witchcraft pamphlet was released (Sharpe, 2000), being the first out of many serious treatises on the matter. Since early modern witch-hunting is ascribed to the Reformation and the intolerance of the Church in general, the demonic part that stemmed from the identification of witches as agents of Satan was emphasised. Sometimes scholars publicly denounced countermeasures against witchcraft, but these attempts were vastly different in tone, length or depth of research (Sharpe, 2000). Many of them were sensationalist and remained appealing only to the ill-informed. The trials continued throughout the 15th century even when the witch-hunting had already

stopped during the Restoration and the last sentence, overturned by a judge, took place in 1712.

With the turn of the century, European politics and philosophy were radically reoriented and assimilated as part of a movement that was taking over the continent: the Enlightenment (Porter, 2001). Preceded by the Scientific Revolution in the late 16th and 17th century—including Copernicus' *De revolutionibus orbium coelestium* (in English *On the Revolutions of the Heavenly Spheres*) (1543) and Newton's laws of motion and universal gravitation in *Philosophiæ Naturalis Principia Mathematica* (in English *Mathematical Principles of Natural Philosophy*) (1687) (Guicciardini, 2009; Neuber et al., 2015)—scholarly communications resented the dogmatic character of the church and the imposed monarchy.²⁷ The Age of Reason (1685–1815) emerged in France but grew into a full-blown predominance throughout Europe, questioning long-established authority and embodying rational thought as a key factor for the improvement of humanity (Knox-Shaw, 2004).

During the Enlightenment, the rigidity that had prevailed in the Renaissance regarding the safeguarding of texts within a small circle of intellectuals mitigated. Similarly, sticking to the well-established aesthetic rules and conventions lessened so that authors could both depict and address their works to a broad segment of the social spectrum. Out of the canonical genres, theatre proved the crowd-pleaser, probably because it was the most provocative, including resentment toward aristocratic pretensions (Love, 2008). Engaging large numbers of people together in intimate spaces, it focused on actors and actresses who enacted the stages of being in a lavender haze and getting out of it because of betrayal and tragedy. Plays stemmed from literary pieces, but generally did not require the audience to have any prior knowledge, making it a different approach to reading that was accessible to most. The act of reading, however, was

27. Copernicus (1473–1543) was a mathematician and astronomer who formulated a model of the universe where the Earth was placed at its centre instead of the sun (Neuber et al., 2015).

Isaac Newton (1643–1727) was a key figure in the Scientific Revolution whose mind was always in motion, research showing that there was never a single avenue toward knowledge for him, let alone a single form in which it might be captured (Dry, 2014).

not always straightforward and simple: legal and clandestine coexisted during this era. A French-born way of publication, the distribution of clandestine books was “partially regulated by a system of taxes and tariffs designed to protect legitimate printers and booksellers” (Dipiero, 2014: p. 143). Like illicit affairs, clandestineness relied on a small-scale distribution or did not even make it to print.

Within the works that were not meant to get to print are included those from Anglo-Irish author Jonathan Swift.²⁸ Swift hoped to undermine neoclassical decorum, as evidenced by the puzzles that he included in *Miscellaneous Poems* (1735), as seen on the following riddle:

From heav’n I fall, though from earth I begin,
 No lady alive can show such a skin.
 I’m bright as an angel, and light as a feather,
 But heavy and dark, when you squeeze me together.
 Though candor and truth in my aspect I bear,
 Yet many poor creatures I help to ensnare.
 Though so much of heav’n appears in my make,
 The foulest impressions I easily take.
 My parent and I produce one another,
 The mother the daughter, the daughter the mother²⁹ (p. 339).

Written around 1720, Swift believed in a wit-against-wit situation between him and the readers, be they his friends or an unknown recipient, who needed to go beyond literal meaning to unveil his enigma. Though taking a human shape through personification, the answer to this riddle

28. Jonathan Swift (1667–1745) was an Anglo-Irish satirist, his most celebrated novel being *Gulliver’s Travels* (1726) (Quintana & Luebering, 2023).

29. For clarity purposes, the consonant “f” in the original text has been replaced for “s” as it would be employed nowadays.

is on its very title, “On Snow”, which one can infer from the references to white shades, potential danger and a “heavenly origin”. He is said to have begun his riddle collection as a source of entertainment between him and his cohorts, “a game belonging more to the province of speech than literature belonging” (Powers, 1990: p. 41).

As an era that celebrated human reason and disapproved of human folly and excess, formal qualities such as regular metre and rhyme, polished images and verbal wit were highly esteemed, as was the satire that prevailed and that naturally met strong resistance from the Church (Cordner et al., 2023). Bacon’s empiricism and Descartes’ rationalism, along with other philosophical contributions, laid the first stone for the grounding of reason, the basis of which was religion tolerance and individual liberty (Manzo, 2022).³⁰ In literary salons and coffeehouses, this train of events led up to the questioning of social norms from some marginalised parts of the population, such as upper or middle-class women. Mary Wollstonecraft’s *Vindication of the Rights of Woman: with Strictures on Political and Moral Subjects* (1792), an extension of the *Rights of Men* (1790), responded to scholars who did not believe that women ought to receive formal education.³¹ Although her viewpoint was addressed to middle-class women and it was therefore limited to her social status and Christian values, she maintained that women were deserving of the same fundamental rights as their male counterparts (Moore, 2016).

The Early Modern period witnessed a series of life-changing events that revolutionised the way of thinking of British people, starting from the coming back to classical trends to a humanist self-awakening (Grendler, 2006). These conversations notwithstanding, their respect and deep admiration towards Greek and Roman ancestors did not stay in the past, the remnants of which can be seen in everyday life.

30. Francis Bacon (1561–1626) and René Descartes (1596–1650) were two influential philosophers from England and France, respectively. Their ways of thinking have been traditionally categorised as opposites, but are rather complementary (Manzo, 2022).

30. Mary Wollstonecraft (1759–1797) was a British writer and an advocate for women’s rights, today regarded as one of the founding protofeminist philosophers (Moore, 2016).

Figure 2

Coat of Arms of the University of Sheffield



For instance, this tendency can be seen at the University of Sheffield's motto (Figure 2), inspired by Virgil's verse 490 of Book 2 of "the Georgics" (29 BCE), where he states *Rerum Cognoscere Causas* (to discover the causes of things). The culture of enjoying mystery and solving riddles had been fostered and cultivated throughout these years—but would reach its peak in the Victorian era, just to evolve into the most astonishing techniques as the contemporary era progressed.

2.3. Victorian enigmas: the power of secret communication

Although the Enlightenment proved to be culturally significant for both religious inconsistencies and personal growth, it did not yield people all the answers that they needed. When the 19th century began, such purely rational beliefs were questioned by the unexplained. The understanding of the world filled with unprocessed emotions and events went beyond the senses, which no one could provide empirical reasoning for. The literary depiction of the human experience felt rather incomplete (Brown, 2010), since disregarding feelings as a non-essential part of the individual development was unrealistic. While also including this metaphysical dimension, rationality was not seen as the opposite of emotional awareness, but rather emphasised as two sides of the same coin.

Romanticism embodied such ideals as an intellectual orientation that took over Western Europe from the late 18th century to mid-19th century. Albeit

often perceived as a rejection of order and harmony, the introduction of chaos and the unknown was meant to balance the dominance of the previous strict rules out. Rationality was not necessarily frowned upon (Brown, 2010) since the rationalisation of emotions could actually aid artistic production, but the spontaneous and transcendental were encouraged at the same level. The obsessive interest in folklore and the appreciation of nature went back to inner struggles, the focus on which was more important than sticking to traditional procedures—see, for instance, the difference between Mary Shelley’s *Frankenstein or, the Modern Prometheus*’ (1818), the focal point of which was the weird and the monstrous, and William Wordsworth’s *Lyrical Ballads* (1798), where he explored an overflowing stream of feelings.³² The following extract belongs to the latter (Wordsworth & Coleridge, (2005) [1798]):

The stars of midnight shall be dear
To her; and she shall lean her ear
In many a secret place
Where rivulets dance their wayward round,
And beauty born of murmuring sound
Shall pass into her face (p. 243).

In “Three Years She Grew”, Lucy, the person that Wordsworth alluded to, had died long before she could be the object to the poet. Even though there is a sense of tragic loss and inevitability, it also dwelled upon the romantic themes of personal growth (Gravil, 2007), the beauty of nature, and the “secret” or enigma that death is.

32. Mary Wollstonecraft Shelley (1797–1851) was a British romantic author who became a paradigm of the woman writer, *Frankenstein; or, The Modern Prometheus* (1818) being her most-well known novel. It involves a Swiss scientist who creates a seemingly scary creature when conducting an experiment (Kuiper, 2023).

William Wordsworth (1770–1850) was a British poet who helped to launch the Romantic movement in Britain along with other authors such as Charlotte Smith (1749–1806) or Samuel Coleridge (1772–1834) (Labbe, 2011).

The Romantic period coincided with the accession of the eighteen-year-old Queen Victoria in 1837, which marked the beginning of the Victorian Age.³³ Her royal role differed considerably from the disreputable Hanoverian monarchs that preceded her—George IV and William IV—and her long reign “was to witness the increasing unification of Britain and a moral transformation of society” (Richards, 2009: p. 3). This unification did not cause a homogeneous cultural consolidation between Scotland, England and Wales, since there were substantially different cultural developments that remained within each region. For example, all of their own legal, educational and banking systems were differentiated and recognised as valid. The Victorian Era lasted until the queen’s death in 1901, the social and cultural footprint of which was of historical and literary significance.

In Victorian society, fine arts were regarded as an advantageous tool to express social ideals and convey the nation’s moral values. Encouraging the production of artistic and literary culture was perceived as a valuable and even rewarding enterprise that would upgrade the audience’s education and help to develop critical thinking. Critically acclaimed works of British artists decorated both public spaces and state institutions as well as well-attended open exhibitions, where people would indulge in the discussion of innovative trends in painting and literature (Moran, 2009). The middle-class access to literary resources was further facilitated by “‘the fee-based lending’ or ‘circulating’ library, epitomised by Charles Edward Mudie’s Select Library in 1842, an English publisher who increased the stock by over 950,000 volumes” (Moran, 2009: p. 15), and a considerable amount of money was invested in the development of the National Gallery.

These early Victorian standards were determined by the thriving influence of Neo-Classical formality and traditional schemes as well as the burgeoning language and sublime topics from the Romantics (Duffy, 2023). There was no consensus on where beauty originated or how it

33. Queen Victoria (1819–1901) played a complex role in the history of Britain during her long reign, where she shaped the powerful role of the Crown and redefined the concept of female leadership (Chernock, 2019).

should be approached by the artist, let alone their role in the process. How skilled a painter or writer was depended on the handling of stylistic techniques and on whether the genre choice was deemed appropriate. The figure of the author radically split into public and private self, and such separation needed to be grasped by the reader. These principles and guidelines were widely embraced and “institutionalized through reviews, critical writing, universities and national bodies like the Royal Academy” (Moran, 2009: p. 18). Nevertheless, by the time mid-century hit, the most acclaimed works were those which focused on the real world instead of the unattainable or unrelatable for the general public. Thus, there was a blend between the “high” and “popular” culture theme-wise, even if being a professional writer was still limited to some.

In the mid-Victorian period, there was an on-going debate on the ability of understanding, predicting, and managing aspects of the mind, both in the scientific and spiritual realm. On the one hand, artists had been starting to include characteristics of literary realism in their works, especially the perks of a mundane life and human existence, a great resource that made the novel feel more relatable. Though she barely witnessed the transition towards this artistic movement, Jane Austen³⁴ encouraged its main purposes by also using biting sarcasm and harsh social commentary:

My first displays the wealth and pomp of kings,

Lords of the earth! their luxury and ease.

Another view of man, my second brings,

Behold him there, the monarch of the seas! (1886 [1815]: p. 59).

In *Emma* (1815), the namesake outwitted a mercenary suitor when solving his riddle. The “my first” part is a reference to “court”, since it “displays the wealth and pomp of kings”, while the second alludes to “ship”, as described in “the monarch of the seas”, and so the right answer

34. Jane Austen (1775–1817) was a British novelist whose main subject of writing was human nature, including the similarities and differences between people, such as the dependence of women on marriage to secure a favourable economic position (Brownstein, 2011).

is “courtship”. Albeit anonymous for most of her life, she explored the lack of independence and financial power of women while married and the unfavourable social conditions that they encountered should they decide to pursue an improved social standing or detach their economic security from that of their husbands’.

Political and social progress prevailed over fantasy and magic. Hence, this period has been called “the age of science” due to the increasing certainty that the cosmos was regulated by immutable natural laws rather than the divine whim, which was often proved unfounded and immediately dismissed. Relying on human senses was praised among the scientific community as opposed to looking for extrasensory evidence to support a hypothesis. At the same time that this solid scientific tendency existed, some medical practitioners and scientists endeavoured to present controversial practices such as hypnotism as an empirical procedure when discussing the brain’s unconscious, because the mind was thought to be partly controllable (Noakes, 2004).

Going beyond the earthly existence could carry fatal consequences should the mediation between the living and the dead not go according to plan, and the execution of such events were always a dangerous enterprise which was strongly criticised by most professionals. The supernatural defied any solid definition, but it usually referred to “a realm that the human mind cannot conceive” (Bown et al., 2004: p. 9). These metaphysical beliefs haunted the Victorians because they hoped to unravel the mystery of their own being, get a last opportunity to speak with a deceased loved one or understand what the inevitability of death meant. In both the literary world and reality, séances served as a narrative device to accomplish this goal, as they provided an explanation to justify secret communication with the dead.

The role that spiritualist mediums played quickly turned into the most ambiguous and problematic facet of such manifestations over the following decades, since the interpretations varied greatly in quality and layout from one expert to another. Most of them claimed to be able to portray the “independence of spirit and matter, the survival and immortality of the spirit following bodily death, the eternal progress of

all in the other world, and the possibility that under certain conditions spirits of the dead could manifest themselves to the living” (Noakes, 2004: p. 27). Therefore, the experience of regulars attending séances in Britain in the early 1850s included tables getting ripped out, the levitation of objects by—presumably—long-gone spirits and secret coded messages from professed messengers of death.

Scientific advancements included other types of codes, the telegraph becoming key in the transmission of information during the 19th century because it revolutionised communication by accelerating decision-making and overcoming long distances (Schiffer, 2008). For example, transmitting sensitive financial data through public telegraph lines required a code language that was shared by both parties. The codes developed by banks were consistently updated throughout the years, since the main purpose of this common system was to hide the real intention of messages as well as to reduce substantial telegraphic charges. Far-reaching or confidential messages had to therefore be “closely coded in order to disguise the meaning as far as possible; where there is not the same need for secrecy, economy of words is the primary objective” (Mussio, 2016: p. 239). In other words, not only were coding systems useful for keeping information away from some, but they were also a way to avoid wasting precious time. Financial and technological institutions could benefit from innovative ways of control-processing data, which eventually led to a social transformation.

Codebooks were such extremely valuable intelligence documents that they demanded a security system (e.g., a safe or a locked compartment) that was permanently protected by a guardian, a skilled manager, or a trustworthy accountant (Stamp, 2006). Only some of the members of the personnel were in charge of the custody of these types of books, their responsibility carefully shifting during office hours so that codebooks could be seen and used by as few people as possible. The fewer people that were granted access to such information, the less likely it was for that data to fall into the wrong hands. This was the beginning of renewed interest in enciphering, where some scientists, mathematicians or linguistics would start working on new ways to keep information a

secret.

In the middle of the code fever, English scientist and inventor Charles Wheatstone³⁵ was responsible for the Playfair code, in hopes that the frequency analysis (also known as counting letters) of ciphers would be easier to break (Cowan, 2008). The system (Table 1) consisted of replacing a digraph within a set of letters with the previous one on its left—if the original letter was on the first column, it would be replaced with the last one of the previous row, and so on. Therefore, if anyone wanted to say “RED”, the right code would be “TCL”.

Table 1

Playfair cipher

C	E	S	A	Z
Y	O	L	D	V
I	U	M	B	T
R	F	Q	H	J
P	K	X	G	N

The downside was that both parties needed to keep a physical codebook to use it. Initially rejected by the British authorities when his author presented it for the first time, lord Lyon Playfair³⁶ convinced the military to use it (Lehning, 2020) and proved to be useful until cryptographer Joseph Mauborgne in the United States and the German team cracked the secret code.³⁷ British codebreakers—both professional and amateurs—were far from giving up though, and their enthusiasm inevitably influenced other areas such as literature.

35. The incorporation of the Playfair matrix in 1856 by Charles Wheatstone (1802–1875) was a great improvement on existing enciphering methods, since the security of most was not high at the time (Cowan, 2008).

36. Lyon Playfair (1818–1858) was a British scientist, liberal politician and Wheatstone’s friend, hence the cipher’s name (Blatchford, 2023).

37. Despite being in charge of information assurance in the Office of the Chief Signal Officer, Joseph Mauborgne (1881–1971) was the only cryptologist in the Signal Corps and we was frequently sought out for his opinion (Bellovin, 2016).

Detective fiction reconciled this scientific aspect of solving a case—or cracking a code—and the unknown parts of the exploration of the mind. The narrative genre, powered by the incorporation of the profession of detective just a few decades before, started to gain popularity in the mid-19th century (Link, 2023). The seemingly impossible crime, the falsely accused suspect and the observation and gradual revelation of the true culprit from the detective all fell under the category of this kind of fiction, which often regarded superficially convincing evidence as insufficient to solve a case (Rzepka, 2005). Mysteries solved by private detective Sherlock Holmes and his companion Dr. John H. Watson in their shared apartment in 221B Baker Street, a series of fifty-six short stories and 4 novels written by Scottish author Arthur Conan Doyle, became the most influential British detective narrative of the century.

Expanded to novel length due to its increasing demand, this type of story usually had criminal tints to it because it was deeply concerned with social regulation. The social hierarchy was always re-established at the end of the novel by catching the criminal and therefore the genre became “diagnostic, prescriptive and corrective: all transgressions of the law are predictably followed by the restitution of social order” (Smajić, 2013: p. 71). It still favoured the *status quo* over political change. That being said, the authority that the police held was often mocked and their wit was deemed faulty, so that the main character’s reasoning became crucial to compensate for such lacks. Sometimes their cooperation was based on deductive methods and a purely rational approach, but, parallel to the spiritual emphasis that was happening at the time and the literary themes that were being explored, detective fiction also aimed at the integration of experimental techniques within the resolution of a story.

Bringing occulted supplements disguised as rationalism to the table allowed supernatural practices to be introduced, where unusual skills such as clairvoyance, telepathy and intuition “are not just uncannily reminiscent of the detective mind-reading powers and miraculous feats of deductive reasoning, but are *versions* of these practices, and vice versa” (Smajić, 2013: p. 181). Hence, the increasing interest in such genre coincided with that of spirituality because both disciplines aspired to explain mysteries,

even if the scientific community still had its reservations about anything regarded as paranormal and would continuously challenge ghostly scenes. Holmes exemplifies this hybridisation of the norm by admitting that there are areas that his human methods cannot cover and that external supernatural forces would come in handy to solve an enigma while regarding the portrait of Hugo Baskerville “as evidence of both hereditary and spiritual reincarnation” (Smajić, 2013: p. 182). Criminal offences were puzzles that needed to be solved.

As a precursor of contemporary detective fiction, the sensation novel also shared some of its psychological features and the need to dig deeper into the past to understand the present, superseded by riddles and enigmas which set the mind to work (Ascari, 2007). It was said to be “sensational” partly because of its content: usually a crime was introduced, most of the time in the form of an intentional homicide. Crime was often the ultimate outcome of toxic family relationships in apparently decent and bourgeois settings. These properties, conjoined to an expanding book market and an exponential growth of the reading public, marked the beginning of a comprehensive genre of fiction. It stood halfway through the two main artistic and literary movements of the century—Romanticism and Realism³⁸—as well as midway between Gothic superstitions and modern mysteries.

There are various genres and contexts that this type of novel drew inspiration from, though it is with the Gothic setting that it shared the closest affinities (Cox, 2019). At the same time, the significant influence of Dickens³⁹ and stage melodrama, along with the historical context—including “sensational” journalism, bigamy trials and the consequences of the divorce law reform—paved the way for domestic realism in fiction. Though the question of women had already been debated for a

38. Realism coexisted and eventually replaced Romanticism since it helped to depict the lives of ordinary people (Lesjak, 2021).

39. Charles Dickens (1812–1870) was one of the authors who drew on popular motifs and characters. His novels *David Copperfield* (1850) and *Great Expectations* (1861) include coming-of-age stories as well as a colourful set of popular characters, ranging from orphans to servants (Patten et al., 2018).

long time in Parliament that preceded the sensation novel, this genre was culturally significant to explore their role in society.⁴⁰ Sensation stories were “novels with a secret” (Marsh, 1995: p. 1), in the sense that they depicted an apparent model neighbourhood or community of seemingly polite and upstanding citizens, but whose scandalous secrets would be uncovered in due time. The actual purpose of the novel is to detect and show illicit affairs, clandestine meetings and longing stares that exist under their paper-thin plans of respectability to the reader. Both the main and secondary characters live a double life where they usually hide some type of immoral characteristic such as adultery, madness, or murder. The greatest expectation lies on the very moment where such secrets are unveiled so that characters are revealed as deeply flawed instead of inherently heroic.

A second perspective worth mentioning is the structural properties of the sensation novel, where there is “an apparent disintegration of narrative authority, caused by the introduction of secular mystery as a main ingredient of plots” (Brantlinger, 1982: pp. 2-3), even if these might also be common in other genres. Once again, there are enigmas that no one knows the answer to, and the resolution of which the characters might or might not even want to endure. The last principle that the sensation novel operated on was the psychological analysis of the main characters, which was under scrutiny for the longest time due to its non-empirical nature, and partly inspired by the Newgate novel.

The Newgate novel was published in England from the 1820s until the 1840s, and typically glamorised the criminals’ lives that they portrayed (Falke, 2016). Though apparently vastly different in style, these principles were complementary. The rich blend of popular and high culture is part of the sensation novel, which “like all genres is itself a mixture of sometimes contradictory forms, styles, and conventions” (Brantlinger, 1982: pp. 2-3), but which ultimately achieved a decent demand from

40. An example of earlier records of making progress towards women’s rights is Lady Caroline Norton, who left her husband in 1836 and fought for equal justice for women. The Married Women’s Property Act and reform of the English Marriage and Divorce Laws were passed by the Parliament mainly through her intense campaigning (Norton, 1982).

readers.

A few years later, the incorporation of some female writers to the novel scene following The Matrimonial Causes Act (also known as the Divorce Reform Act) in 1857 diversified the authors' voices, causing a disruption of the traditional form. The possibility of getting a divorce enabled women to be more vocal and create a multi-voiced, more open-minded narrative. The wife's interests did no longer depend on her husband's approval should divorce be granted. Women's legitimate reasons to initiate the process for a legal separation were still severely limited to adultery and "only four women successfully petitioned Parliament before 1857 compared to 140 granted to men" (Humpherys, 2011: p. 43). Those who wanted to talk about their social disadvantages but did not feel brave enough to do it upfront chose supernatural themes such as ghosts. They hoped that these creatures would act as a metaphor and capture women's experiences and the ghostly role that they embodied in Victorian society. In this sense, this was a more subtle way to attempt to secure their individual financial survival and potential future independence.

Writing professionally as a woman, however, was perceived as somehow distasteful or inappropriate. Not only were professionalism and intellectualism intrinsically linked to masculinity, but the notion of a female writer was also seen as physically not feminine enough. Damsels in distress were pale in comparison with those of its Gothic predecessors, since women were now the ones *causing* distress, and the theme of female imprisonment "remains prevalent, though metaphorical confinement as a consequence of patriarchal structures is as common as literal imprisonment" (Cox, 2019: p. 42). This literary revolution made medical professionals fear that women would not want to submit to their conventional role anymore and began to be interested in diagnosing "female illnesses", such as the well-known "female hysteria". Their reaction did not stop writers such as Catherine Crowe, Amelia Edwards or Charlotte Riddell⁴¹ from publishing several sensation novels within

41. The most well-known works from Catherine Crowe (1803–1876), Amelia Edwards (1831–1892) and Charlotte Riddell (1832–1906) are *Manorial Rights*, *The Phantom Coach* and *The Uninhabited House* and *The Haunted River*, respectively.

their work which later became essential in the emergence and further development of the modernist and postmodernist experiments in narrative form (Humpherys, 2011).

While all their works are not rare to find among university syllabuses as Victorian popular fiction, they were heavily criticised at the time and were definitely not part of the contemporary academic canon, except for *Jane Eyre* (1847) and *Wuthering Heights* (1847) by the Brontë sisters (Cox, 2019).⁴² In a review of Collins's *The Woman in White* in 1861, a literary critic for the *Spectator* warned about the upcoming threat of "a new variety of the sensation novel . . . the whole interest of which consists in the gradual unravelling of some carefully prepared enigma" (Gilmore, 2016: p. 297), which sums up the reluctance from some traditional academics towards these works. Their appeal reached far beyond scholarship and academic circles, as they represented a place where readers would encounter all types of confusing yet engaging devices.

One of these resources was a "red herring", which stands for "a fact, idea, or subject that takes people's attention away from the central point being considered" (*Cambridge Dictionary*, n.d.). Say, for instance, that a woman named Flora has been murdered. The victim's friend Stella knows that her husband was the culprit, but she cannot prove it because there is no body, so there is technically no crime. Stella also knows that the husband is already seeing someone else, and that his new lover took out a big life insurance policy. Having this information that will act as a red herring and securing an alibi by making sure that someone else confirms that they were together that evening, Stella can kill the husband knowing that the police will be likely to arrest the mistress, even though she is not the one that committed the crime. This is the type of dynamic that was sought in Victorian times, and that would keep the audience entertained. Undertaking enigmas or mysteries as a recreational endeavour, whatever

42. These books were written by Charlotte and Emily Brontë, respectively. Their younger sister Anne also wrote some notable works such as *Agnes Grey* (1847). All three focused on main characters that did not belong to privileged classes, and their focal point is less on a world of social interaction than it is on intense subjective experience (Glen, 2002).

their chosen kinds of puzzles, was often frowned upon until this pastime became increasingly popular among puzzle makers or solvers.

Household Words, a British weekly magazine edited by Dickens, carried on with this pastime in the 1850s by introducing its series of “Puzzles for Prizes”, the aim of which was “to make competition universally attractive by setting each week Puzzles suited to all types of intellects” (Gilmore, 2016: p. 299). By 1879, a writer in *All the Year Round* was already commenting on what he interpreted as “Puzzle Mania” as a result of the printed puzzles that had become more and more important and culturally established within the UK.⁴³ Even though they were often considered an ambiguous feature of the Victorian print market, they had the advantage of being manufactured quicker than other products and served for both alone time at home as well as tedious train journeys. Puzzles, like detective stories and sensation novels, worked well with serialisation due to the restrictions of one monthly publication that held readers in eager anticipation for the next. An enigma that was introduced at the end of the year would go unanswered until January, so that the solvers would go back to December to keep thinking and waiting about what the right response would be (Hecimovich, 2008).

Many of these puzzle forms could come across as distracting or misnamed—see, for instance, the “Scripture Enigma” of the *Sunday at Home* or the “Historical Enigma” of the *Leisure Hour* (Gilmore, 2016: p. 300), which were actually acrostics. In other words, they were poems or other types of writing composition in which the first letter, syllable or word of each new line or paragraph spelled out a different word or phrase. These verbal riddles that often went by the term “enigma” in the 19th century were often indistinguishable from other types of riddles that were described as puzzles or charades. Getting to the ultimate solution of a puzzle was a creative process that required imaginative and lateral thinking skills. In this sense, such active and engaging rhetoric was

43. During the Victorian era, there was a growing recognition of the political union between England, Scotland, Wales, and Northern Ireland, leading to the use of “UK” to encompass all regions, rather than just “Britain”. Therefore, from now on this is the term that will be used.

parallel to that of the novel, so that they could benefit from each other. Solving enigmas, regardless of the textual length, constituted a form of morally and intellectually literary challenge for many readers.

This “mania” for puzzles notably aided their expansion as they were released in more journals and their publications began to be seen as a potentially effective tool in areas other than leisure. Puzzles could also be used, for instance, for educational purposes, especially if they were rewarded with money or material gifts (Hecimovich, 2008). One could win a set of books if their charades were chosen to be the most original or if they found the solution to a specific riddle which could be inspired by classic novels or common knowledge. Cash prize was already tempting, but sometimes seeing one’s creative work in print was even more gratifying: beating hundreds of contestants and earning a reputation as a puzzle expert was the ultimate jackpot. For wannabe poets, the introduction of puzzles in verse represented a potential power move: if they were granted the rare chance of seeing their own production on a magazine or journal, they could either write original poetry or use satire to parody well-known prose authors or traditional approaches to poetry depending on the task that was given. There were some other solvers that preferred to remain anonymous, so they designed a new version of themselves for strangers to see, often through “what the vituperative author of the piece on ‘Puzzle Mania’ called ‘euphonious’, alter egos for submitting their entries” (Gilmore, 2016: p. 301). Winners used the most creative run of pseudonyms which matched the energy of their own wit when attempting to solve a conundrum.

Enigmas were not limited to monthly magazines and weekly journals, but they turned out to be especially cryptic in newspapers. They often came into sight in agony columns, a type of written bric-a-brac which usually consisted of miscellaneous pieces of information from different origins in various formats (Turner, 2018). There could be urgent notices of missing pets as well as fundraising appeals for numerous organisations or condolences for the loss of a loved one. Advertisements for all sorts of products, including questionable or “miraculous” medicine and household items, were also common features within these columns (Cooke, 2023).

Their most emotional—and popular—side included personal statements on long-lost relatives or missing friends or short letters from people who sought external advice over a specific topic.

The term “agony”, however, referred to the encrypting nature of communiqués that Victorian readers could find packed into “the narrow columns of the front page of most newspapers” (Turner, 2018: p. 430). Some of these messages included codes and ciphers of varying complexity, or at least a suspicious tone that pushed the readers’ eyes into a squint. Such vagueness made this section more sensational and the unclear information more addictive. At least 40 encrypted advertisements were published in the *Evening Standard* from 1879 to 1881 and a series of 25 enigmas in the *Daily Telegraph* from 1884 to 1887. The following excerpt dates back from a coded piece of information to arrange a date in 1869 in *The Times* (Clay: (2007) [1881]):

Monday, October 11, 1869.

SKZPCJJY. Bcyp Dyllw, kccr wmsp bgqrpyarc b dpgclb zclcyrf
rfc ugijmu zwrfc jyic. Pmu slbcp rfc qryp q. Amkkml qcy spccxcq.
Dcyrfcpucgefr.

Wmspq Zgawajc.

This cipher operated by substitution, the most popular way of encrypting written communications. Inspired by the ancient Caesar cipher, where each letter in the plaintext was substituted by some other letter that was an agreed number of positions up or down the alphabet, this one went the extra mile. In this case, the real letters were replaced by using a left shift of two, and therefore S becomes U, K would be M and so on. The writer of this message actually wanted to say “UMBRELLA. Dear Fanny, meet your distracted friend beneath the willow by the lake. Row under the stars. Common sea-breezes. Feather-weight. Yours, Bicycle.” (Clay, (2007) [1881]: p. 8). Both the sender and the recipient’s identity were protected by their nicknames, and the clue about the place should be enough for them to understand where to go. Many of these messages were secret interactions between lovers—often in the midst of a forbidden

romance or socially unacceptable relationship—and most of these remain unsolved.

This Sherlockian obsession with the agony column exemplifies how innovative two people had to be in the Victorian age to get away with confidential weekly communication. Converging somewhere between the public and private sphere, these ciphers epitomised inquisitiveness, which was extremely appealing to the observer of human eccentricities. Newspaper regulars found that their messages were “veiled in an air of mystery, with a view of blinding the general public, but at the same time give a clue unmistakable to those for whom they were intended” (Turner, 2018: 433). Preferring to hide in the peripheral vision of many due to the newspaper’s widespread popularity, they provided mysteries that the readers could attempt to solve. They would, however, most likely never know if their guess was correct or not, unlike the riddles or puzzles where the right answer was published shortly after to check who was wrong. Such a way of catching the attention of readers precedes many attempts of reaching and sustaining mass audience today and how game-changing the format and style of a text can be in achieving this goal (Hecimovich, 2008).

Some other avant-garde rebels also attempted to make an enigma out of art. Throughout the 19th century literary nonsense emerged as a broad categorisation for the combination of formal syntax and semantics with a humorous absence of sense, where logical reasoning balanced out the lack—or excess—of meaning (Lecerle, 2002). Oral folk wisdom was the first source this subgenre drew upon, including children’s games, songs and rhymes; the second being the intellectual private jokes and absurdities of court poets and scholars of various kinds. Taking the Latin prestige and making a parody out of it as well as indulging in religious and political satire was common, so what set these texts apart from traditional mockery was their exaggeration and hyperbolic nonsensical effects (Hołobut & Chłopicki, 2017). One of the greatest examples is *Alice in Wonderland* (1865) by Lewis Carroll, where the main character is said to be the only sane among the mad, and whose journey is filled with mathematical and linguistic riddles.

The *fin-de-siècle* urged writers to reflect on the multiple changes that the artistic world had experienced over the last century and overstep their self-imposed boundaries. Spiritualism and industrialisation were in a dialogue with contemporary technological and psychological theories. Science tried to find any common ground with the uncanny feeling of finding something extremely frightening and deeply beautiful at the same time, like telepathy or clairvoyance powers (Noakes, 2004). The uncanny was the effect in writing that the supernatural caused, because “whereas the supernatural relates to the external, to disturbances in the exterior world, the uncanny is psychological, representing disturbances kin the internal body, or mind” (Grimes, 2011: pp. 6-7). Haunted by the fear that selfhood was only a myriad of illusional material because nothing was certain, the possibility that the mind could no longer be controlled, and the realisation that, in fact, it had never been, was a low blow for the Victorians, who sought for answers elsewhere. These spiritual studies were not opposed to the medical and psychological studies of the Gothic and dark Victorian, but rather in a negotiation stage where they could both get inspired by and learn from each other.

Folk wisdom tinted every step that the Victorians took, but also impelled them to embrace the numerous adjustments that they were experiencing due to their ever-changing literary nature. The re-evaluation of classics and traditional formalities, the incorporation of mystery, the return to the domestic realm and the beginning of avant-gardes made this époque to be one of the most prolific ones in the history of British literature, the traces of which are palpable today. The new versions of these stories in the last thirty years also involve “a crime, event, personage or text from the past functions as the catalyst for the retrieval/revision of that past in order to discover some new clue that will change our perceptions in the present” (Pulham, 2010: p. 159). They encourage connections between different periods of time, but preserve the British nostalgia for the 19th century. Although some might have historical inaccuracies for the sake of modern interpretation, some of these Victorian-inspired media products include *Bridgerton* (2020—present), set in the early 1800s Regency period, and the multiple adaptations of Sherlock Holmes (e.g., the BBC

series *Sherlock* 2010–2017). The turn of the century, however, was about to take these groundbreaking ideas to the next level, providing the artists with the revolutionary input and social acceptance that they needed.

2.4. From war ciphers to contemporary approaches to mystery

The death of Queen Victoria in 1901 brought unparalleled peace and prosperity for the UK. Some of the inventions of this period that provided a solution to social concerns include the typewriter, the telephone and the radio. These devices had a groundbreaking impact on the way relationships and broadcasting worked, as they enabled international communication by linking both family and friends and mass audiences across great distances (Seaman, 2002). The former's earliest patent was granted to Alexander Graham Bell⁴⁴ in 1876, even if they were previous developments in regard to mechanical acoustic devices and electromagnetic telephones (Esmail, 2013). Bell's model 102 telephone became the most popular and longest-lasting physical style of telephone in the early 20th century; the radio began as wireless telegraphy in the 1890s by Italian inventor Guglielmo Marconi⁴⁵ and spread the radio fever in the 1920s, where people that could afford such an investment rushed to the stores to buy it.

Another string of innovations and advanced technologies that solved daily inconveniences, albeit mundane, caused a wholesale acceleration in problem-solving for everyday tasks (Fairley, 1972). Household items such as the electric iron or the cooker were a game-changer in the domestic sphere and in labour relations, the increasing automation of these activities being carried out by working-class women. It is not entirely

44. A striking number of 19th-century communications technologies were products of an inventor's interest in deafness, including Alexander Graham Bell (1847–1922), who had a deaf mother and wife. Nevertheless, his problematic view of this community as a threat to the human evolution is evidenced by his commitment to teaching students to read lips and speak aloud as opposed to learn sign language, and his further opposition to deaf people getting married to each other (Esmail, 2013).

45. Guglielmo Marconi (1874–1937) popularised and patented the usage of radio waves, establishing his *Wireless Telegraph & Signal Company* shortly after his demonstration of his wireless device in London (Raboy, 2016).

surprising that women were responsible for many of the inventions in this field: Josephine Garis Cochrane (1839–1913) came up with the first commercially successful design of an automatic dishwasher in the US; German entrepreneur Melitta Bentz (1873–1950) invented the paper coffee filter brewing system in 1908 (Pilato, 2016). Other late 19th century products by female inventors that resolved knowledge gaps within the engineering field include the mathematical line-divider by Hertha Ayrton (1854–1923) in 1884, a drawing instrument to divide a line into any specific number of parts and/or alter the size of figures (Bruton, 2018) and the multiple patents that were granted to Verena Winifred Holmes (1889–1964) between 1921 and 1958. Holmes developed a wide range of engines, including innovative marine, locomotive, diesel, and internal combustion engines (Stanley, 2004). Thus, their introduction portended huge changes for the general population.

The evolution of the national British railway, which caused a railway mania in the 19th and 20th centuries (Carter, 2008; Hollow: 2019), homogenised time by creating standardised schedules. This era, after all, was the witness of a time where vehicles such as the automobile and the aeroplane made their unprecedented debut (Roach, 2013). As a consequence, there was a revolution in personal mobility that sparked the reshaping of the world in which British inhabitants lived. Thus, the habits and expectations of the average novel reader also experienced a considerable change.

The multi-layered Victorian plots with elaborate stylistic devices and intricate narrative were eventually replaced by short stories that could be read in a few hours after work or on public transport. The development of public libraries and the commercial libraries attached to shopping streets encouraged the purchasing of books in the early 1930s and had been the primary source for many readers prior. While in 1940 a paperback could be bought for the price of a packet of cigarettes and allowed the average library subscriber to borrow two books a week, a three-volume novel retailed at 31s 6d⁴⁶ in the 1880s (Wilson, 2011). The library market was

46. The equivalent to £76 today.

the ultimate responsible for the longevity but also the fall of the three-volume story and the establishment of the one-volume novel as between 70,000 or 80,000 words (approximately 200 to 300 pages).

Many subgenres emerged in the interwar years, including thrillers and science fiction, but the detective story experienced its golden age in the 1930s. Reading detective fiction was a conflict between spiritualism and logic, where “the séance—whether faked or actual—is more than simply a plot device and has to be taken in the context of other means of information gathering” (Stewart, 2009: p. 76). The interwar detective fiction moved away from puritan Britain and the celebration of rural Englishness towards a more politically reactionary perspective, Agatha Christie symbolising the “whodunit” form.

Christie’s audience actively enjoyed magic performances and the deception and entertainment in the appearance of death. Her works, far from encouraging conservatism, succeeded to encompass a growing middle class (Michailidou, 2022) while satirising the xenophobia often associated with the genre. Christie’s male detective, Hercules Poirot, often mentions his difficulty when integrating socially with the English and gets mistaken as French despite being Belgian. He is indicative of a wider avant-garde trend of depicting men unlike the masculine heroes hitherto, having a non-conventional appearance and personality. Similarly, there was virtually no representation of main characters in her 70s/80s prior to the incorporation of Miss Marple.

Under the right circumstances, detective fiction assumed the characteristics of travel writing or even sensation fiction, like the will that is hidden inside a copy of *Lady Audley’s Secret* in Christie’s short story *Greenshaw’s Folly* (1960). The mystery is solved by Miss Marple, “whose precursors include the amateur female detectives of sensation fiction, such as *The Woman in White*’s Marian Halcombe and Braddon’s Margaret Wilmot in *Henry Dunbar*” (Cox, 2019: p. 73).⁴⁷ Implicit and explicit allusions to the latter as well as Victorian nostalgia, represented

47. *The Woman in White* by Wilkie Collins and *Henry Dunbar* by Mary Elizabeth Braddon were published in 1859 and 1865, respectively.

by a Victorian mansion (the “folly”), the inheritance plot and the back and forth switching of identities between mistress and servant, linked this story to its predecessors. Christie exemplified how enigmas belonged to the past, the present and the future, and the puzzle fever in the Victorian era would continue to change in form throughout the 20th century.

Figure 3

Author's attempt to solve Cain's Jawbone



Cain's Jawbone (1934) fused the “whodunit” subgenre and the puzzle mania, the ultimate murder mystery presented as a “puzzle novel” by Edward Powys Mathers⁴⁸ under the pen name Torquemada. This concept was extremely innovative, since it consisted of a series of 100 pages that the reader needed to rearrange in order to find the right sequence of the story (Figure 3). Solving this puzzle had a substantial cash prize for anyone who managed to find the answer, which made it extremely appealing for the audience, yet challenging. As the very book advises, this story was not for the faint-hearted, because there were multiple coherent

48. Edward Powys Mathers (1892–1939) was a puzzle expert who published this book at the height of the so-called golden age of detective fiction (Hughes-Castleberry, 2023).

combinations for the story but only one of them was actually correct. Literary references, weird wording and red herrings acted as potential distractions that exponentially increased its difficulty, impossible to solve without having an extensive literary education and/or paying numerous visits to the library. The title alluded to the first ever murder weapon in the Bible story of Cain and Abel,⁴⁹ and so the reader also had to provide names of the six murderers in the story and those who got killed by them. Although it has experienced a revival in the last few years due to the influence of social media, this book had only be solved by a handful of people by the end of 2020 (Flood, 2020), which spoke volumes about how arduous of a task it was.

While the literary world was trying to keep up with these numerous avant-gardes, science was also overwhelmed by the considerable progress that was being made. The attachment to the telephone as opposed to that to the radio or television radically privatised the communication experience (Trotter, 2013). The main goal of both radio and telephone sought to get to the listener's consciousness and came across as a private monologue rather than an external authority. Through these devices, private exchange of information was enabled, which became a significant advantage for personal use, but which stood out over the rest due to the specific historical conditions of the time: the need for war ciphers.

Codes during the war often involved the ciphering (derived from the Arabic word *sifr*, meaning "zero") of the alphabet, such that a specific number of letters were replaced by others by some rule or applied principle that the two (or more) parties had agreed on. Encrypting by substitution is the simplest way to cipher a message, where each letter must be transposed into another letter a given number of positions up or down the alphabet like lovers used to do in newspapers in the Victorian era (Turner, 2018). Cracking the code and revealing the real message that was hidden in-between an apparently illogical series of

49. In the Bible, Abel and Cain were two brothers who made sacrifices to God, but only Abel's was favoured. Cain then murders his younger brother and gets punished with a life of wandering. Like in any other passage, there are multiple interpretations to the relationship of the two and how the story evolved (Vermeulen, 2014).

digraphs depended on the kind of interaction between various types of numerical and linguistic components or machinic processes that was demanded from the recipient, some of them being closely linked to the syntax, semantics, or the structure of language. The most problematic and weakest part of any cipher lied on the fact that “it must produce an output that can be translated back reliably into language—and language is full of redundancies or mechanic elements” (Connor, 2016: p. 24). If some intruders spoke the same language as the two parties involved in the exchange of messages, there was always a chance that they would be able to decipher the code and understand pieces of information, notwithstanding its difficulty.

The system progressively got more difficult as the dynamism of such mathematical-linguistic operations added conjunction of words and numerals to the equation. The transfer of ciphers had to embody the most complex forms of transposition if used in the war, the way of decrypting often involving the usage of a key of numbers in an established keyword. For instance, the machine Enigma, invented by German engineer Arthur Scherbius shortly after World War I (WWI), was an electromechanical system which resembled a typewriter and encompassed a series of rotors which shifted letters along. The enciphered letter would light up on the lamp board whenever the operator pressed the key for the plaintext letter of the message and its interchangeable rotors would rotate every time this happened to prevent the cipher from staying the same (Lehning, 2020). This system was completed with a plug board where pairs of letters were transposed at the front of the machine, which resulted in a combination of two systems that generated up to 103 sextillion possible settings. Hence, the Germans thought that the coding that the machine produced was unbreakable. Adopted by their forces between 1926 and 1935, this device was regularly updated with the recording of patterns of a set of specific examples.

In January 1940, Enigma traffic was broken by the British for the first time and would routinely do so after the information that they were granted by the Poles, who decoded the cipher as early as 1932 (Inman, 2020). The codebreakers at Bletchley Park, the top-secret country house

and estate of the Allied codebreaking during the World War II (WWII) in Milton-Keynes, England, made significant progress when they discovered that there always had to be some kind of zero-degree formula that was frequently exchanged and that could be identified by them (Reeds et al., 2015). Bletchley Park's tasks included registering Morse-coded radio communications of the Axis powers (German, Japan and Italy) or decrypting apparently innocent code messages such as *Keine besondere Ereignisse* (translated as "nothing special to report"). Additionally, the team kept track of every person, unit, or weapon that was mentioned throughout these communications, including technical terms and recurrent phrases within the German military jargon.

According to the official website of Bletchley Park, a significant proportion of the employees were recruited from the Women's Services; the Women's Royal Naval Service (WRNS), the Auxiliary Territorial Service (ATS) and the Women's Auxiliary Air Force (WAAF). By 1945, 75% of the staff of Bletchley Park were women, 60% being in uniform, the remaining being hired through the Civil Service. The role of these workers proved to be key in the evolution of intelligence tactics of the British team, as they could provide the army with valuable information and protect them from future planned attacks (Smith, 2021). After Germany's defeat on May 8th, 1945, and Japan's formal surrender due to the atomic bombings of Hiroshima and Nagasaki, WWII ended in September of that same year.

The population of all the countries which had participated in the war and those which had witnessed the conflict from far away needed to adjust to the aftermath of warfare (Berensmeyer, 2016). Needless to say, this was not an easy task, and an amalgam of voices throughout the UK emerged as representatives of the different sides of the conflict: soldiers returning half their weight who had to manage to live a normal life after experiencing atrocious conditions;⁵⁰ women who had contributed to the

50. The Post-Traumatic Stress Disorder (PTSD) of some soldiers would result in struggling to live a normal life once they got back home, cursing as they sleep-talked because flashes of the battle came back to them in nightmares (*PTSDUK*, 2022). Untreated PTSD in military veterans affected the way they perceived daily life after severe trauma caused

army effort yet remained completely invisible; authors who experimented in their writing to escape the guilt, fear and sorrow that their new reality offered. Still unsure as to how to address the convulsed times that overruled periods of peace throughout the 20th century, and questioning what humanity was capable of, the new millennium entered to approach problem-solving in a completely different way.

This era provided users with huge technological advancements that solved what seemed unsolvable. The human genome map, an international project that comprehensively studied all of the DNA of a select set of organisms, launched countless medical breakthroughs in this century, the last update dating of 2022 at “complete genome” level (*National Library of Medicine*, 2022). Knowing what genomes are made of and generating the first sequence of the human genome is key for many medical treatments, which ultimately could lead to a higher quality of living. Other inventions such as smartphones and GPS navigation have also made life easier by reshaping how humans perceive their daily life. Furthermore, the consolidation of the internet⁵¹ and more complex video games have added infinite extra possibilities to leisure (Egenfeldt-Nielsen, 2013). Nowadays, a classic literary mystery can escape traditional textual forms to other interactive ways, and the endless possibilities that are offered have a greater chance of succeeding through social platforms.

Social media platforms are popular app choices to connect with relatives and friends as well as to stay informed about what is happening around the globe. Their adding has contributed to make books popular or announce releases to a wider audience (Alaimo & Kallinikos, 2017). Through them, many content creators can show their book hauls, do a recapitulation of what they have read in a month or rank their favourite

by combat stress, life-threatening events and their participation in troops, and could potentially become dangerous symptoms that the soldiers did not know how to cope with.

51. Since the beginning of the new millennium, the number of people that have permanent access to Internet, even outside the house, has increased exponentially. The International Telecommunication Union (ITU), a specialised agency of the United Nations, estimates that approximately 5.3 billion people (more than 65% of the entire population) use the Internet in 2022, which represents an increase of 25% since 2015 (3 billion) and a 45% since 2007, where 79% of the world was offline (2022).

and least favourite titles; *Cain's Jawbone*, albeit initially written in 1934, is said to have experienced an unprecedented revival in 2021 upon its re-printing according to the publisher introduction in most recent printed edition in Spain (Powys Mathers, 2021 [1934]). Going viral significantly helped some debut authors, the downside of this hype being that they could face a greater public backlash than ever before should it not meet the audience's expectations (Kim, 2015).

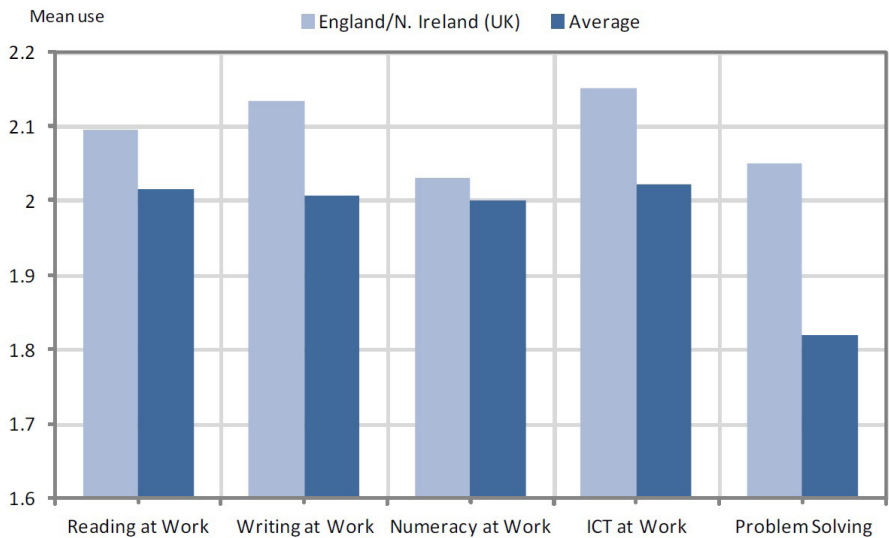
On the one hand, getting to a wider audience through social media has enabled users to read the news on their phone, if carrying a physical copy with them is not ideal, which solved the problem of adjusting space and weight. On the other hand, the incorporation of these devices demand time from their users, and have therefore been sometimes hard to reconcile with the traditional habit of reading. There is a growing body, however, that supports the benefits of reading for pleasure for both educational purposes as well as personal development (Clark & Rumbold, 2006). According to the *Research Evidence on Reading for Pleasure Report* by the Education Standards Research Team in the National Department for Education (2012), reading enhances text and grammar comprehension as well as breadth of vocabulary, providing the reader with a sense of self-confidence and a greater knowledge and understanding of others' cultures.

The Survey of Adult Skills conducted by the Programme for the International Assessment of Adult Competencies (PIAAC), a worldwide study of assessment and analysis of adult skills of the Organisation for Economic Co-operation and Development (OECD), measured "adults' proficiency in key information-processing skills—literacy, numeracy and problem-solving—and gathers information and data on how adults use their skills at home, at work and in the wider community" (OECD, 2012) in over 40 countries. The latest data seems to conclude that "there is a strong and positive association between higher literacy proficiency and social outcomes in England and Northern Ireland" (OECD, 2012). This means that, on a scale from 1 to 5 (and below Level 1), being 5 the highest literacy and numeracy level, people with lower scores are less likely to think that their actions matter in politics or participate in volunteering activities. They also suggest that these skills—including

problem-solving—are heavily used in the workplace, as seen on Figure 4 (OECD, 2012):

Figure 4

Average use of information-processing skills at work



Note. This study shows levels of different information-processing skills in the UK compared to the average of the participant countries. Skills use indicators are standardised to have a mean of 2 and a standard deviation of 1. There is a clear correlation between a higher level of literacy and problem-solving, which indicates that this ability can be developed through reading, writing, and practising mathematics.

Buying fiction in the 21st century still provides the reader with the same feeling that it did to buyers in the previous centuries: it is a way to access different perspectives as an outsider, to negotiate how much the reader finds situations or characters relatable and to compare these affections or disaffections to understand how they operate in the relationships one has (Adiseshiah, & Hildyard, 2013). Unlikeable characters, anti-heroes and unreliable narrators make some of the elements that keep the audience entertained and engage them in the story, where no one can be trusted,

while maintaining their suspension of disbelief.

As suggested by Kantar Media's research in 2021, 53% of UK adults claimed to having read at least one book in 2020—most likely a physical book—, 35% of those adults being categorised as “heavy readers” if they had read over 10 books within a year (McClelland & Powell, 2021). When asked about their propensity to buy different formats of book, the answers in the *Booktrust Reading Habits Survey* conducted by DJS Research in 2013 spread out relatively evenly between those who purchased items monthly (18%), every 1 to 6 months (24%) and those who never did (25%), the weekly buyers standing at 6%. Those who bought books every 7 to 12 months or less came to be the 15% and 12%, respectively. When it comes to frequency, the same study suggested that half of the British community said that they read physical books either daily or weekly, the number being significantly lower for other formats (DJS Research, 2013).

The average reader in the UK prefers to read in the evening, before going to bed or on their way to work or university, Londoners being twice as likely as other people throughout the nation to read while commuting, particularly Londoners who read or listen to audiobooks on the tube and buses (YouGov, 2020). Roughly the same number of people stated a preference towards fiction over non-fiction (35%) or have no preference (36%), while leaning more towards non-fiction stood at 20%. Biographies and memories are the favourite subgenre within non-fiction, while crime and thriller as well as fantasy are the go-to option for most readers who buy fiction. Reading habits and preferences vary greatly from country to country and so do the ranges of genres available to the readers, although the availability of foreign literature is more accessible than ever. Despite taxes and customs, multiple websites provide millions of books from around the world at little to no delivery cost. Not only has this significantly helped the distribution of books overseas, but has also solved the problem of getting access to world literature.

In the UK, paperback editions remain the most popular due to its lower price and comfort as opposed to hardback. Given multiple options and selecting all that applied, only 47% of the respondents claimed to

typically read hardback copies, while 60% opted for paperback books. Audiobooks, one of the latest incorporations to the literary market which is particularly convenient for an individual to listen to a story while carrying out other activities, stood at 8%, and were surpassed by E-books at 24% (YouGov, 2020; Wordsrated Statistics, 2021).

Even though its popularity and updating accelerated the most in the 21st century, the electronic book dates back from the 1930s, where Bob Brown thought that the written word could not keep up with the modern pace and wrote about his idea that he titled “The Readies”. It would take 40 years for his concept to become reality, since the e-book was invented in 1971 by American author Michael S. Hart (1947–2011), who also founded Project Gutenberg as the first provider of copyright-free books (Gilbert, 2015). Although he defined the landscape of online publishing, Spanish school teacher Ángela Ruiz Robles⁵² had already registered two patents for an automated book where learning materials were displayed by pressing buttons and later rotational reels (Rodríguez, 2014).

E-books were crucial as an outcome of problem-solving since they adjusted to the hectic environment of many cities nowadays and allowed the easier and quicker acquisition of multiple items at once. When using these devices, books are usually downloaded from the Internet as files that can be used offline on any computing gadget with a software installed that enables the device to display a given file format, PDF and EPUB being the most popular ones. These digital files consist of a body of text and/or images that are suitable for being sold electronically and usually optimised for easy downloading. Not only can they be used for recreational purposes but have also been studied as an interactive tool for students whose teachers follow methods such as Problem-Based Learning,. Through this method, problem-solving is enhanced by letting students seek answers independently to solve problems through the application of previous knowledge (Wang, 2020).

52. Spanish teacher and writer Ángela Ruiz Robles (1895–1975) believed in the power of visual elements such as images when reading, but also in the benefits of having a light device with condensed information that could be carried around.

The proliferation of e-books changed the publishing industry completely and allowed readers to obtain books at a more affordable price while suggesting early predictions about the potential replacement of paper books (Zhang & Kudva, 2014). While the purchase of this format increased during the COVID pandemic due to shop closures, solving the problem of how to maintain a reading habit during a global health crisis, they did not beat the acquisition of physical copies and there is no anticipation that they will replace them in the future. The current digital sales stand at 25.8% in contrast with 271 million printed books that are purchased in the UK each year (Wordsrated Statistics, 2021).

The digital era has proved to be crucial to solve literature-related problems. Readings can now be stored digitally in mobile apps that serve as a database of books, quotes, and reviews (Oudenaar & Bullard, 2023). Registered users can keep track of what they are reading and what they have already read as well as add new releases that they might be interested in to their to-be-read pile without paying any fees (Nakamura, 2013). In creating art, this type of innovative ideas is of the essence due to the overwhelming amount of people trying to succeed and the increasing access to publishing. The more pop books, music or video games that the user can relate to, the more resources that they have to be engaged in the acquisition of problem-solving (Dietrich et al., 2021). Puzzles and riddles do not limit themselves to purely textual forms, and music is another way of taking literary production to the next level. Poetry started as songs, which is why literature and music are so closely linked together and why lyrics of songs can be perceived superficial and basic, or, on the other side of the spectrum, exceptionally profound and metaphorical. Different melodies and seemingly innocent lyrics are easy ways to encrypt a message, like hiding a deeply hurt narrative in a bop song. The diversification of the number of channels on TV as well as the Internet enables written literary production to turn into a wide range of artistic forms, be they visual or aural, and ultimately reach a wider audience.

Similarly, the development of computer technology, especially that of videogames and virtual reality, shaped the evolution of modern immersive

experiences, escape rooms being one of the puzzles taken from literature to real life. They provide people with an escape from reality by entailing a set of rules in a temporary situation that go back to the normal rules of the world once the game is completed (Egenfeldt-Nielsen et al., 2013). They are often inspired by literature and folklore and sometimes require previous knowledge, written clues such as letters or codices being common features of this type of activities.

In these locked rooms, a group of people enter a themed space and have a timer that starts as soon as the door closes behind them. Usually ranging from 45 minutes to 2 hours, the participants need to solve as many puzzles as they can to get out before running out of time (Griggs et al., 2022). All their personal belongings must be left behind, and there is a person or a team who monitors their activity and sometimes helps if needed. A walkie talkie or a phone is provided, so there is always some means of communication between the group and the game masters who monitor the activity. Additionally, some companies also incorporate a panic button should anyone suffer from claustrophobia or feel anxious during the event. A clock is often visible to the players so that they can control their own pace, the ticking of which urges them to work faster. Most escape rooms involve padlocks and missing keys, ciphers, and cooperative tasks (Fernández-Martín et al., 2022; Hou, 2023). Some other objects or sounds, however, might be red herrings and act as a distraction, moving players away from the right answer if they are not careful. The most complete experiences include actors and actresses who might scare the players or act as a mediator and trade a special clue. The escape room genre ranges from horror to fantasy and some are based on popular culture, including the series and TV adaptations *Game of Thrones* or *Harry Potter*.

The four different houses at the Hogwarts School of Witchcraft and Wizardry, the fictional boarding school of magic in *Harry Potter* (1998–2008), rely on diverse systems to access their common room. The way to enter Hufflepuff’s is tapping the barrel two from the bottom, middle of the second row in the rhythm of the founder of the house, “Helga Hufflepuff”. This is the security device “to repel non-Hufflepuffs, tapping

on the wrong barrel, or tapping the incorrect number of times” (Rowling, 2015). Both the Slytherin and Gryffindor houses trust a shared password, but the only thing that grants access to the Ravenclaw common room—well-known for its quick-witted and creative members—is actually a riddle. If students want to enter, they need to give the right answer to the eagle knocker, as seen on the following passage from *Harry Potter and the Deathly Hallows* (Rowling, 2007):

Luna reached out a pale hand, which looked eerie floating in midair, unconnected to arm or body. She knocked once, and in the silence it sounded to Harry like a cannon blast. At once the beak of the eagle opened, but instead of a bird’s called, a soft, musical voice said, ‘Which came first, the phoenix or the flame?’

‘Hmm ... What do you think, Harry?’ said Luna, looking thoughtful.

‘What? Isn’t there a password?’

‘Oh no, you’ve got to answer a question,’ said Luna.

‘What if you get it wrong?’

‘Well, you have to wait for somebody who gets it right,’ said Luna.

‘That way you learn, you see?’

‘Yeah ... Trouble is, we can’t really afford to wait for anyone else, Luna.’

‘No, I see what you mean,’ said Luna seriously. ‘Well then, I think the answer is that a circle has no beginning (p.587).

This conversation between the main character and Luna Lovegood, Harry’s friend and member of the Ravenclaw house, shows how much worth astuteness still holds. Upon their entrance to said common room, pupils must wait until the next person comes and tries to solve it themselves if they do not provide the right answer. Popular culture and modern folklore have transformed the way riddles and puzzles are presented, now far away from the traditional representation in the court:

the mechanics, however, are fairly similar.

The current literary market urges authors and artistic creators to adapt themselves to a diverse public that demands a variety of content as well as comfort and affordable prices while balancing the rapid pace of a potential technological outgrowth. The hectic atmosphere of busy cities demands new formats and light readings for people who do not have much free time; the involvement of social media has been proved fundamental for the revival of classics, setting literary trends and organising long-distance book clubs; books keep revisiting the past, while also paving the path for the future. Above all, literature has escaped the exclusively conventional textual format and has sometimes become a real-life immersive experience by active game interaction or richly poetic language in pop lyrics. What the future holds for the 21st century is unknown, but the continuous stream of unheard-of literary approaches and unparalleled ideas integrated within a wider framework sets the precedent for the still long way to go.

3. Problem-Solving Skills and Global Citizenship

Solving real world problems in real time given constraints within one's environment has proved to be essential for survival throughout history: during Apollo 13 space mission, carbon dioxide levels were dangerously increasing in the space craft and the crew managed to make them fall by assembling and taping a temporary handmade appliance out of the materials that were available onboard at the time (Sarathy, 2018). Having failed two days into the mission, lunar landing was aborted, and the crew needed external help to ensure a safe return to Earth. Had it not been for Katherine Johnson's previous work on backup parameters and charts, the way back home would not have occurred (Shetterly, 2020).⁵³ Her problem-solving skills, which she applied to the development of calculations of orbital mathematics and later on to a real-world life-and-death situation, enabled the success of the first US crew flights (Shetterly, 2016). Current world problems that also require these skills include increasing sea levels and atmospheric water vapor, the approach to which is key to stop them from worsening.

Problem-solving, however, is far from being a punctual skill that is only required in extreme situations. People are confronted with problems of entirely different nature on a daily basis, be they trying to extract a broken light bulb, choosing whether to study at university or not or deciding which piece of furniture to buy when being on a budget. Even if these problems might differ in various ways and therefore the skills that they would benefit from may also vary, they all share a common core—that is, a situation that cannot be solved simply by performing an action, but that demands a recourse to thinking (Bassok & Novick, 2012). For instance, changing the route once there is traffic congestion deviates the driver from going straight to work from home, and requires evaluating which ones suits best according to several factors such as time and place.

To have a problem implies that the solver is given at least certain

53. Katherine Johnson (1918–2020) was a female mathematician who worked the National Advisory Committee for Aeronautics (NACA) and later at its successor the NASA from the 1930s until the 1980s. Johnson contributed to place the first human on the Moon, but her trajectory equations for astronaut John Glenn's orbital space flight that set her reputation in 1962 (Shetterly, 2020).

information about it, be it the goal, the conditions, the tools or operations available, initial information or access to resources (Newell & Simon, 1972). Translating a German article into English, for instance, implies that there is a subset of sequences that satisfy the criteria of English syntax, grammar structure and style within all possible sequences of English words. This problem usually requires that a) the solver is proficient in both languages, b) the expectations or preferences of the reader are clear and potentially c) the solver knows the context of the original text in German. If the solver is unable to meet the demands of the situation, they will also be unable to figure out the problem.

According to *Cambridge Dictionary* (n.d.), problem-solving stands for “the process of finding solutions to problems”, whereas some more exhaustive definitions include “a cognitive processing directed at transforming a given situation into a goal situation when no obvious method of solution is available” (Mayer & Wittrock, 2006). While said term can be used to allude to valuable skills or strategies in everyday life, facing a problem within the academia according to Unterrinter and Owen (2006) simply refers to the—often unknown—steps that are required to achieve a specific goal. From a logic perspective to the direct consequences that the development of problem-solving skills has on the brain, the multiple approaches to acquiring said skills exponentially increase key abilities such as critical thinking, creativity, and resourcefulness. Not only can this enhancement become pivotal in the workplace as well as at an emotional intelligence level, but it can also become a tool that people can apply to major issues such as the 17 Sustainable Development Goals from the United Nations.

3.1. An Introduction to Reasoning and Logic

Problem-solving constitutes a series of complex abilities that coexist in the brain, reasoning and logic being a significant part of its foundation.⁵⁴

54. Some contents within this section such as the truth tables were recorded and summarised from a meeting with Dr. Jordi Valor Abad, professor at the Faculty of Philosophy and Educational Sciences at the Universitat de València, Spain.

Etymologically, logic alludes to the process of reasoning or the science of thinking, since it employs laws or rules of thought (Ab et al., 2019). Broadly speaking, it refers to the act of drawing conclusions in order to reach a certain goal (Leighton, 2004). Likewise, reasoning within Epistemology—a branch of philosophy that focuses on the theory of knowledge—is one of the traditional ways in which our beliefs are justified and determine whether they constitute knowledge or not (Bernecker & Pritchard, 2011). From a set of beliefs that are believed to be justified, reasoning aims to extend said justification to the verity of other beliefs. Such a field has evolved throughout time and place: Cartesian epistemology drew conclusions from the evil demon problem⁵⁵ so that either the possibility of deception had to be excluded or the possibility of infallible knowledge beyond our immediate sensory impressions denied. However, traces from scepticism that were found in early Buddhist texts in ancient India held the view that it was unlikely to acquire knowledge of metaphysical nature or to be categorical with regard to the truth-value of propositions (Jayatilleke, 1963), even if they did not dismiss it completely (Chatterjee, 1977).

The four main epistemic sources to guarantee that a piece of information constitutes knowledge are (a) perception—which provides information about what we experience right now—, (b) memory—things we experienced once or multiple times in the past—, (c) other people’s statements—which might be controversial, but there is enough evidence to prove that they are valuable in the quest for knowledge—and (d) reasoning (Steup & Neta, 2020). As stated in the previous paragraph, the main function of reasoning is building convincing arguments that allow the conclusion to be justified by the premises. There are two basic ways to do this: through ampliative or non-ampliative reasoning. Whereas “deductive reasoning” (i.e. deduction) goes from a general premise to a

55. Descartes supposes that “some evil genius not less powerful than deceitful, has employed his whole energies in deceiving me; I shall consider that the heavens, the earth, colours, figures, sound, and all other external things are nought but the illusions and dreams of which this genius has availed himself in order to lay traps for my credulity”. By doubting everything, however, he can at least be sure that he is not being misled into falsehood by this demon (Descartes, 2000 [1641]).

particular conclusion, “inductive reasoning” (i.e. induction) operates the other way around and gets to a general conclusion from a set of particular statements (Patel et al., 2005). Table 2 shows an example of each:

Table 2

Deduction vs induction

Deduction
The UK is an island nation on planet Earth.
Both Guildford and Sheffield are locations within the UK.
Therefore, both Guildford and Sheffield are located on planet Earth.
Induction
Riven has feelings for Darcy, whom he sees every Monday taking the train from London Waterloo to Oxford.
Every Monday since they met, Darcy brought a latte from Costa.
Therefore, Riven thinks that Darcy will also get a latte next Monday from the Costa coffee branch at Waterloo station.

Non-ampliative reasoning is the traditional method commonly labelled as deduction—that is, the information within the conclusion that is already contained in the premises. As shown on the previous example, a hypothesis can be confirmed through deduction, but also allow others to be discarded. For instance, from the two statements “no flowers are human” and “hydrangeas are flowers”, one can ascertain that hydrangeas are not humans.

Following *modus ponens*—a Latin term for logical inference—, the system that allows humans to evaluate the truth of premises is based on a set of constants that establish the connections of both truth functions with quantifications and identity. Universal and existential quantifications assert that the property or relation applies to all or some members of the domain, respectively, as shown by the main logical connectives or truth

functions: negation (“no”, $\neg$), conjunction (“and”, $\wedge$), disjunction (“or”, $\vee$), material implication (“if...then”, $\rightarrow$) and biconditional (“if and only if”, $\leftrightarrow$). These variables are established through a common mathematical and philosophical notation of terms—except for negation, which operates in a different way. Their value is true (T) or false (F) depending on each combination as stated in Table 3, p and q being any two premises:

Table 3

Truth tables

P	Q	$P \wedge Q$	$P \vee Q$	$P \rightarrow Q$	$P \leftrightarrow Q$
T	T	T	T	T	T
T	F	F	T	F	F
F	T	F	T	T	F
F	F	F	F	T	T

On the first and second column, the first and second premise are categorised as true or false, respectively. For instance, if premise 1 (P) is true and premise 2 (Q) is false and they are both connected by a disjunction ($\vee$), the conclusion will be true; but if premise 1 (P) is false and premise 2 (Q) is false too and a conjunction ($\wedge$) is used, then the statement will be false (Badesa et al., 2007). Though this might be confusing in some cases *a priori*, it should be noted that not every “T” necessarily stands for *absolutely true*. In classical logic, there is no such thing as “maybe”, only “true” or “false”, and the value “true” is given to any element that *is* or *could* be “true” so that no possibility is ruled out.

For any set of propositions to be valid, there needs to exist an interrelation between the premises (Shramko & Wansing, 2020): while both “The University of Sheffield is a higher education institution in the UK”, and “A cut crease is a technical term for a make-up technique” are true statements, they have nothing to do with each other and therefore are not logically correct. Moreover, this table accounts for the most common logical connectives that only involve two elements, but more could be added if necessary (for instance, r on top of p and q), and the tables would

proportionally increase in variables according to the number of added elements. While being a practical categorisation, not all knowledge can be encapsulated through this system, hence the inclusion of ampliative reasoning or informal logic to the table.

Mill's *A System of Logic* (1846) established logic as the art and science of reasoning: nowadays, informal logic is “informal” rather than “formal” primarily because it studies arguments as they occur in natural language discourse. According to *The Stanford Encyclopaedia of Philosophy*, informal logic seeks to “understand and improve thinking, reasoning, and argument as they occur in real life contexts”, such as in public discussion and debate or intellectual exchanges as well as in interpersonal relations, among others (Groarke, 2022). In this sense, it attempts to provide ways in which arguments can be evaluated in a certain period of time and in a specific social context. Likewise, it studies the nature and definition of an argument as well as the valid criteria for argument evaluation and argumentation schemes, including fallacies, notions of validity or the rhetorical and dialectical aspects of arguing that are related to linguistics.

Ampliative arguments can also be referred to as “induction” or “abduction”. In both cases, the conclusion contains information that goes beyond what the premises entail (Gunderson, 2014). As opposed to deduction, where a general principle applies to specifics, a general proposition is drawn from a particular case. They are deductively incorrect, and have not gone without critiques, the earliest being by David Hume on *An enquiry concerning human understanding* (1748). According to him, causal inference by purely *a priori* means was impossible, since it relied on personal (and therefore subjective) experience, and specifically a dilemma regarding experience in which “if there be any suspicion that the course of nature may change, and that the past may be no rule for the future, all experiences are useless” (Hume, 2019 [1748]: p. 38). In other words, he alluded to the problematic consequences that operating on the assumption that natural laws and processes in present-day scientific principles have. He thought to be problematic to believe that they had always operated in the same way and would continue to do so, as if they could be applied everywhere in the universe.

These regularities sometimes overcome empirical research: until the 17th century, all swans in the world were thought to be white based on a significant collection of samples, yet black swans were spotted in Australia (Braithwaite, 1970). Unexpected events, albeit highly improbable, are technically possible. Hence, induction will never be infallible. Arithmetic or mathematical induction—a technique that proves that some particular rule or pattern is true from a point on for all positive integers (Barnes & Gordon, 1987)—is considered to be the most reliable out of all of them. It is not *technically* deductive (the conclusion that one comes to is not contained in the premises), but manages to establish certainty for a property that a set number of elements share.

While by no means being an exact science, empirical induction is still how natural sciences operate, since they frame their results in observation and experimentation (Von Kutschera, 1973; Psillos & Stergiou, n.d.). It is not only observed events that need to be delimited, but also those unobserved. For instance, the statement “all metals are good conductors of heat” is universally accepted because of how easy it is for electrons in them to move around, even if not every single one of the metals out there has been discovered and studied. Induction is used in everyday life, its verity relying on how likely said event is. The more probable the conclusion drawn from the premises is, the better the argument is. The highest level of probability is said to be 1 (Turing, 2012 [1945–1946]), which is the certainty that a deductive argument grants, but an ampliative argument can never reach. A statement, however, could be as close as 0.8 or 0.9, and it would be a solid piece of induction. Say, for example that the road is not dry when looking out the window early in the morning. The most likely explanation is that it has rained overnight—although other scenarios such as overnight cleaning are technically possible, but significantly less likely.

Induction uses hypothesis to go from A to B, where the best explanation is given. This method is key to survival, as it allows predictions of future events based on subjective experiences (Robertson, 2016), such as knowing that if one road has no lightning it might be more dangerous to walk through, and therefore dark streets should be avoided at night.

Treacherous situations aside, induction can prove to be efficient on a daily basis. If someone is on their way to work at 6:30 AM and sees that the bakery is open and no one is inside, they might manage to buy a fresh loaf of bread for the day immediately. Not having to wait early in the morning that day makes one think that there will usually be no queue around that time, so they might generalise this event and go to the bakery at 6:30 AM from that day onwards. Generalisations rely heavily on the context, and should not be taken lightly, but are a useful tool to navigate everyday life.

The approach to induction through logic, however, has not always been fixed and steady. During the Victorian era, the British mathematical establishment grew suspicious of algebra and analysis since they both relied on seemingly arbitrary symbolism and logic (Henderson, 2014). Writer and mathematician Lewis Carroll, well-known for having anything from multiple to no clear references within his literary works, and working in the field of symbolic and mathematical logic as part of his stories, believed that “while particular symbols might be ‘bewitched,’ ‘worn-out,’ or ‘merely conventional’ the systems by which they were organized could be designed so as to be at least formally coherent and that this formal coherence could become a new site of value” (Henderson, 2014: p. 81).

In this sense, John Venn’s contribution to this field began by exploring some abstract problems of series formation within formal logic, which was a pillar of his Moral Sciences teaching load at the time.⁵⁶ In the Victorian Era, formal logic encompassed multiple strands of discourse including a renewed interest in traditional logic, rooted in Aristotle and the school of Scholasticism. His papers soon resulted in a Venn diagram, a graphic tool to solve logic problems in *Forms of Logical Proposition* (1880a). He developed further what he had already offered a glimpse of in a paper for the philosophical journal *Mind* earlier that year:

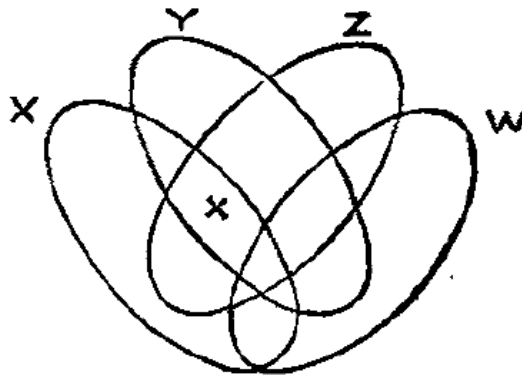
56. John Venn (1834–1923) was a British mathematician and logician who disagreed with trends in the theory of probability, and made a name for himself introducing the famous Venn’s diagram (Dunning, 2021).

What we here have to do is to conceive, and invent a notation for, all the possible combinations which any number of class terms can yield; and then find some mode of symbolic expression which shall indicate which of these various compartments are empty or occupied, by the implications involved in the given proposition (Venn, 1880: p. 345).

Contrary to popular belief, Venn diagrams do not describe any representation of interrelated categories using overlapping circles, since these were not new and already known as Euler diagram.⁵⁷ Venn claimed that a diagram should always include every possible combination of inclusion and exclusion instead, as shown on Figure 5 from *On the diagrammatic and mechanical representation of propositions and reasonings* (1880b) where the area which is asterisked represents “X that is Y and Z, but is not W” (p. 7), as opposed to an Euler’s diagram, “every Y is X”.

Figure 5

Example of Venn’s diagram

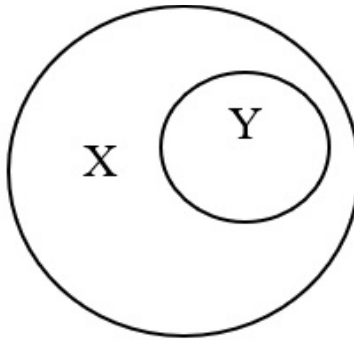


57. Leonhard Euler (1707–1783) was a Swiss mathematician whose prestige was already impressive in his lifetime, but whose discoveries on analytic number theory and complex analysis were extremely influential (Fellmann, 2007).

Statistical concepts, such as yearly murder or mortality averages, were blooming in the first half of the 19th century. Venn's main point in his book *The Logic of Chance* (1866) was that the probability of an event depended on the limiting relative frequency—an idea that some mathematicians and philosophers had already toyed with—with which that event took place in a population of wide extent and of long duration (Kılıç, 1999). The formulation of frequency conceptions of probability involves some reference to universals whether these allusions are implicit or explicit. For Venn, they were strained with the issue of temporality, which led him to deny the existence of “objective” probabilities (Kılıç, 1999). All Venn diagrams are Euler diagrams, but not the other way around, since Euler diagrams only have combinations that actually exist in the real world (Figure 6), whereas Venn diagrams represent every hypothetically possible logical intersection between categories, but they were both important for their time period.

Figure 6

Example of Euler's diagram



Similarly, probability became closely associated with formal logic in mid-19th-century scientific discourse in the UK (Dunning, 2021). In the midst of the outburst caused by Charles Darwin's *On the Origin of Species* (1859),⁵⁸ Venn realised that the series underlying probability calculations should never be apprehended as given in nature if not even

58. Charles Darwin (1809–1882) was an English naturalist whose theory of evolution by natural selection became the foundation of evolutionary studies (Desmond, 2023).

living species were fixed types (Kılıç, 1999). Therefore, the determination of the reference class remained problematic, because it was drawn from frequency of occurrence among a chosen selection of individuals, the criteria for which was undecided.

A few decades later, Alan Turing, a key mathematician for the operations at Bletchley Park during the WWII, was also a pioneer in stating how probability in relation to the validity of arguments worked as shown by the following extract:

If it is known the 20% of men live to the age of 70, then knowing of Hitler only *Hitler is a man* we can say that the probability of Hitler living to the age of 70 is 0.2. Suppose that we know that Hitler is now of age 52 the probability will be quite different, say 0.5, because 50% of men of 52 live to 70. The odds of an event happening is the ratio $P/(1-P)$ where P is the probability of it happening. This terminology is connected with the common phraseology odds of 5:2 on meaning in our terminology that the odds are $5/2$ (Turing, 2012 [1945–46]: p. 1).

Here, Turing defines probability and acknowledges the role of experience when estimating the probability of an event as independent pieces of evidence as well as *a priori* conditions (2012 [1945–1946]). Not only does this make probability prone to mistakes, but it also becomes potentially unreliable due to its subjectivity. Thus, probability does not go without limitations, as it can be biased by multiple factors such as a person's previous (incorrect) knowledge or personal experience. Biases are defined as the stored information in one's mind that has been acquired until the moment that they are presented with a problem, and that might positively or negatively impact one's conclusion (Awasthi & Mohanty, 2021). Rather than sticking to the thought process time, biases also determine which track of thinking a person is using or even which ones one tends to follow unknowingly. As stated earlier in the chapter, these series of interferences occur in ampliative arguments, induction and abduction being the main ones.

Also described as the hypothesis or theory creation, abductive reasoning was initially employed as “the place of explanatory reasoning in *generating* hypotheses, while in the sense in which it is used most frequently in the modern literature it refers to the place of explanatory reasoning in *justifying* hypotheses” (Douven, 2011).⁵⁹ Therefore, abduction goes beyond induction to allow creative inference from vague ideas to develop new knowledge as opposed to the consequent processing of such ideas as both deduction and induction would do. Following a hypothetic-deductive process, abduction encompasses (1) phenomena detection or cue recognition, (2) inference of causal mechanisms, (3) proposition creation/generation, (4) coherent conceptualisation of care situation and (5) case formulation, inference to the best explanation (Noeman et al., 2014). The likelihood for said explanation should not, however, be incorrectly extrapolated, as there seems to be a human tendency to promptly overestimate one’s experiences.

The main difference between abduction and Bayesian probability relies on the fact that while abduction always assigns a confirmation-theoretic role to an explanation, there seems to be a consensus that Bayesians make no explicit reference to the concept of explanation yet have firmly established their view as the predominant view on confirmation (Douven, 2011). The relationship between the two is still very much discussed in contemporary philosophy (Rivadulla, 2018), the lines between the two sometimes blurry. Bayesians determine their degrees of belief or justification by probabilities and, if applicable, likelihoods based on explanatory considerations. As any other probability theory—such as Boole’s inequality or the law of large numbers⁶⁰—Bayes theorem provides the solver with more probabilities once they already have some instead of giving them from scratch. According to mainstream Bayesian epistemology, prior experiences are unreliable, so any assignment of priors is as good as any other, if both are coherent

59. Douven’s italics.

60. These laws refer to (a) the probability that at least one of the events within a set of individual events occurs is no greater than the sum of the probabilities of said set provided that they are finite and (b) the average of random variables converges to its expected value under some conditions, respectively (Dohmen, 2003; Yao & Gao, 2016).

as per axioms of probability theory (Douven, 2011). Whereas the relationship between the two might appear confusing at first, abduction is indeed compatible with Bayesianism, and serves as a very much-needed supplement to it (Douven, 2011).

Getting to the best explanation through reasoning, be it via probability or purely empirical data, is associated with rationality (Pothos & Pleskac, 2022). Though sometimes perceived as the polar opposite of emotion—as evidenced by the historical association in many cultures of the heart as a symbol of emotion and the head as a symbol of reason (Šeškauskienė, 2020)—, they are both two sides of the same coin and depend on each other to function (Cian et al., 2015). Instead of being exclusively tied to the quality of being guided by reason, rationality does not seem to be a static concept and responds to the notion that a person is entitled to their own views and/or preferences, given that these are coherent and adhere to basic rules of logic and probability theory, rather than being subject to changes based on immaterial factors such as mood or context (Shafir & LeBoeuf, 2002). Automatic processes within rationality generally prevent having contradictory beliefs (Broome & Sosa, 2013), like buying a monthly ticket to save money when using public transport on a daily or weekly basis. When intuitive strategies and simple heuristics are employed instead, they might be reasonably effective some of the time, but there is also a risk that they end up producing biases and leading to systematic error in one's conclusions.

One of the ways to limit said biases is acquiring critical thinking, which is also one of the main constituents of problem-solving, defined as follows:

To think critically is to analyse and evaluate information, reasoning and situations, according to appropriate standards, for the purpose of constructing sound and insightful new knowledge, understandings, hypotheses and beliefs. Critical thinking encompasses the subject's ability to process and synthesise information in such a way that it enables them to apply it judiciously to tasks for informed decision-making and effective problem-solving (Heard et al., 2020: p. 2).

Albeit a complex ability to define, it is an organised process that allows a person to evaluate the evidence that they are presented with and use assumptions, logic, and language rationally to fully grasp what underlies the statements of others (Sen, 2011). Justifying argumentation for one or multiple viable options and being able to test and confirm or rule out said hypothesis involves critical thinking in every step (Sen, 2011). This goes beyond simply recalling information to careful goal-directed thinking and the adaptation of knowledge to a context.

While the conception of knowledge has evolved—some of the latest formal incorporations to epistemology include Feminist Epistemologies—, all types of acquisition of knowledge constitute skills that can be gained through theory, practice or both. According to the *Naver Korean-English dictionary* (2023), knowledge (지식) is defined as “a clear perception or understanding of something that is learned or acquired through practice”, while German dictionary *Duden* (2023) describes it as “to have knowledge of something or someone through one’s own experience or information from outside, so that one can then make reliable statements”.⁶¹ Though slightly different definitions, knowledge seems to be intrinsically linked with learning in most cultures.

The process of learning, be it conscious or unconscious, eventually results in a permanent change in a person’s behaviour as a consequence of experience, even though such a shift can be amplified, corrected or even interfered with by further situations: the more experienced one is in a specific field, the more likely it is for them to develop a greater degree of expertise in said field (Robertson, 2016). While commonly associated with educational atmospheres, learning encompasses different styles and varies greatly throughout cultures, resulting in a wide apprehension through multiple methods that can occur in many situations, even without other people being involved at all (Gross, 2012). Hence, learning is key to develop different types of thinking, and ultimately solve problems of different nature.

Since Paul Guilford first proposed Convergent Thinking (CT) and

61. Author’s translation.

Divergent Thinking (DT) in 1956 as two core processes, there have been a variety of paradigms and materials that have been subjected to modelling to explore the cognitive and neural mechanisms that they entail (Yang et al., 2022a).⁶² The former requires organising and structuring information by sticking to a limited number of responses that often involve only one solution from a set of alternatives, while the latter refers to the generation of novel ideas or concepts by exploring many potential solutions. Divergent Thinking is more spontaneous and non-linear, which allows unexpected connections to arise. Though these have been rebuked in latest years—not all problems have solutions that can be ranked, and focusing on selecting the correct answer might dismiss accurate solutions by devaluating minority arguments (De Dreu et al., 1999)—having them as general guidelines can be useful for clarity purposes.

Thinking is not always a conscious, logical process, but *reasoning* is. Multiple kinds of reasoning can be applied when drawing comparisons between previous problems and finding patterns and connections (similarities/differences) between streams of information. Analogical reasoning, for instance, is based on finding a common relational system between two domains, as “when such a common system can be found, then what is known about one situation can be used to infer new information about the other” (Gentner & Smith, 2012); antithetical reasoning encompasses the process to comprehend what the mechanisms that these processes entail are from multiple perspectives so that new relationships between them can be discovered (Tong et al., 2023). Hence, using different types of reasoning when encountering initial gaps of knowledge in trying to solve a problem and learning to identify patterns and apply logic while evaluating pathways enables the discrimination of information.

Reasoning has persisted in time and constantly evolves because it serves as an advantage to human communication, making it more effective and precise (Mercier & Sperber, 2011). Though potentially influenced by biases in an attempt to justify one’s own previous belief system or

62. Joy Paul Guilford (1897–1987) was a 20th-century American psychologist whose work revolved around what he thought to be the nature of human intelligence (Guilford, 1967).

actions and probabilities that do not enable an absolute certain statement most of the times, human reasoning is not a flawed mechanism in general. On the contrary, it frames a specialised device that allows the adaptation to a certain type of social and cognitive interaction. Hence, humans and other animals can solve complex problems, the underlying neuronal and computational principles of which are unknown to some extent (Donnarumma et al., 2016). Games, puzzles and thousands of well-known theorems involve this ability—and more specifically, problem-solving skills.

When reasoning in a problem, the sudden realisation of a solution or of a new promising path to a solution is called insight: while there is a substantial amount of research on some problem-solving components such as the cognitive and neurological processes involved in memory, reasoning, attention and perception, there is little evidence on the role that insight plays in the process (Robertson, 2016). Understanding insight resembles the structure of a joke, since they both involve two unrelated matrices. In other words, the problem could have been solved if the recipient had gotten access to the relevant meaning of a word or phrase (Koestler, 1970). See the following example:

QUESTION: Why did the ketchup blush?

ANSWER: She saw the salad dressing.

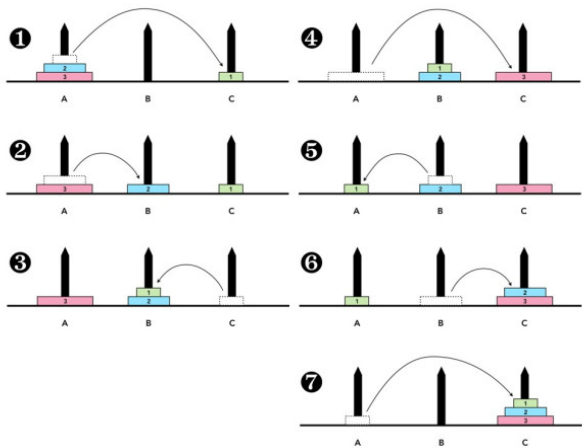
When someone asks “Why did the ketchup blush?”, the solver might not anticipate the potential double meaning that might be related to the sauce, plus the usage of personification makes it a unusual scenario; upon inquiring “why?”, the answer “She saw the salad dressing” makes the first part of the joke make sense, since dressing means both putting clothes on and a liquid mixture that is added to food, especially salads. Rather than not being competent enough to solve the problem, the solver did not know what information was relevant in advance. Though having a well-defined structure, jokes can be examples of ill-defined problems, as the instructions to reach the solution are not available to the solver

from the beginning.

Critical thinking can be applied to both well-defined problems and ill-defined problems. The former involves specified initial conditions, clear goals and evaluation criteria, a defined set of operators for transforming conditions, and at least one solution (Casakin, 2002). They rely primarily on convergent thinking, or the recognition of the similarity of phenomena that initially appear to be different by combining two or more different observations or ideas together (Drago & Heilman, 2012). Both convergent and divergent thinking are, however, required to solve ill-defined problems (Brophy, 2001; De Vink et al., 2021). Ill-defined problems require individuals to define the problem since there are no set goals or clearly defined solution paths, let alone clear expected solutions (Arifin et al., 2017). The solver is in charge of monitoring and regulating the problem-solving process as well as evaluating the final solution(s). The most ill-structured problems are dilemmas, complex, ill-defined and non-immediate, since a correct solution might not even exist (Walker & Leary, 2009).

Figure 7

Tower of Hanoi



The *Tower of Hanoi* game (Figure 7), which consists of three pegs and

several disks of various sizes, is well-known both for entertainment purposes and for being an experimental and diagnostic tool in neuropsychology to gauge problem-solving abilities (Goela et al., 2001). Solvers are given a start state to apply reasoning from, in which the disks are stacked on one or more pegs in ascending order from smallest to biggest size, and the goal state is that the order is reversed through the minimum number of moves in which the disks are placed in descending order on a specified peg. The only three constraints are that (a) only one disk may be moved at a time; (b) when making a move, the rest of the disks must remain on a peg, and never placed outside; and (c) a larger disk cannot be placed on top of a smaller disk (Goela et al., 2001). The *Tower of Hanoi* is an example of a well-defined problem that requires reasoning, since the initial instructions and the objective are presented in a clear and concise way to the potential solver (Colman, 2008).

Most problems that arise in everyday life belong to the other category: ill-defined problems. In fact, much of the argument diagramming (also referred to as “mapping”) and cognitive biases within the history of argument analysis are intrinsically linked to problem-solving and the varying norms that set up argumentative practices in different kinds of contexts. For both, developing problem-solving skills—and therefore enhancing reasoning—is pivotal since it provides the solver with tools to overcome it from multiple approaches, and the criteria to choose the best one. Though a more modern term than reasoning and logic, this ability is very much linked to both concepts, without which there would be no solid ground to build neural processes on.

3.2. The Changing Landscape of Problem-Solving

Whereas problem-solving as a term began to gain popularity in the first half of the 20th century through the Gestalt school of psychology⁶³ and works such as Karl Duncker’s *Zur Psychologie des produktiven Denkens*⁶⁴

63. The Gestaltists rejected structuralism and argued that perceptual experiences are holistic and organised (Wagemans et al., 2012).

64. In English, *The Psychology of Productive Thinking*.

(1935), the importance of decoding information has been studied throughout history. In the Medieval Ages, riddles and puzzles served for entertainment and became an essential part of folklore; in Victorian times, innocent texts could contain secret messages in disguise, and problem-solving abilities could lead to winning a significant amount of money in prizes; in the 20th century, ciphers were essential to hide information during WWI and WWII; the hectic environment in the present day makes these skills valuable to navigate modern waters. Due to this ever-changing nature, there are more types of problems that one can face than ever and that will therefore require different approaches to reach one or multiple potential solutions: problem-solving literature divides problems based on clarity (well-defined vs. ill-defined) and/or the underlying cognitive processes that one needs to go through to solve it (analytical, memory retrieval, and insight) (Sprugnoli et al., 2017).

While clear instructed problems are classified as well-defined, there are others that present a greater level of complexity and fall under the category of “ill-defined problems”, as stated in the previous section. Design problems such as writing a poem or university assignments like essays or a doctoral thesis, or even decision-making dilemmas, are generally considered the most vivid forms of ill-defined problems (Jonassen, 2000) because they demand creativity and critical thinking skills from the solver to determine what the most effective means to achieve a goal are (Birgili, 2015). A PhD student’s objective might include the target audience, the time or resources that they have, the amount of effort that they are willing to put into the thesis, a combination of these or some other factors that they might find relevant to their experience. With regards to the potential reader, some might focus on reaching a wider audience and make their papers more accessible to everyone by paying special attention to writing; others may want the sole attention of a very specific group of people and mostly employ scientific terminology to elevate the content of the paper within their field. Even then, the number of ways to frame a paper within the doctoral guidelines of a university are endless, and so are the approaches to everyday situations.

All these variables belong to human thought and information seeking,

which have been considered to be internal processes for a long time due to the fact that the solver's attention is directed inwards, upon recognising and defining an indeterminate situation (Dewey, 1910). The more attention or resources that the problem draws, however, the more a person's problem-solving effectiveness increases, producing a common problem perception (Chwe, 2001). Similarly, having more knowledge about a defined domain means that the person is better equipped to deal with complex problems within that domain. Hence, a wide range of individual differences in problem-solving abilities is expected. This phenomenon is often associated with the situational theory of publics, which studies people's attitudes and behaviours depending on how they perceive—or do not perceive—those situations that may affect them (Xifra, 2016), and on which problem-solving theory can build on (Kim & Grunig, 2011). Consequently, a greater variety of problem-solving techniques allows the solver to be flexible when encountering uncommon problems.

There are several types of knowledge that might help throughout the process. For instance, declarative knowledge aids the representation of the problem; procedural knowledge presents the set of problem-solving strategies that the solver knows and can choose from; and conditional knowledge, which focuses on deciding which strategy is the most appropriate for the problem that the solver is facing (Urban & Urban, 2023). Declarative and procedural knowledge are interconnected since the latter usually develops as a result of learning the former (Robertson, 2016).

These two are enhanced by metacognitive knowledge, which is the explicit knowledge about cognitive processes as well as the sub-facet strategic knowledge: the latter, in turn, refers to knowledge about the advantages and disadvantages of applying a strategy as opposed to another in a given situation (Nicolay et al., 2022). Metastrategic knowledge also determines where to start when planning the individual steps to reach a desired goal. It monitors the process to detect obstacles along the way and eventually overcome them. It also evaluates how efficient the problem-solving process is to assess the right solutions to the task. Thinking should not be limited to these types of knowledge, as efficient

as they might be on their own, but rather encourage their flexibility when being applied to a problem-solving situation. Described as the ability to apply a skill to novel problems that are different to a greater or lesser degree from the problems that served as the basis for training, flexible thinking encompasses the number of different approaches an individual can employ to come up with a viable solution for a task (Schnotz et al., 2010).

Though slightly differently stated, academics seem to define problem-solving as a step-by-step process: when encountering a problem, people are bound to search for information from previous experiences or the situation itself that might prove helpful. Problem recognition is therefore crucial, said representation being a joint product of the mind and how this perceives the external world (Kim & Grunig, 2011). Consequently, for problem-solving to be effective, an individual must have domain-specific knowledge that enables them to represent the issue in their mind in its complexity. If a painter is asked to attempt to provide a solution to a math theorem the answer to which is still challenging, they might not have enough background knowledge to do it; similarly, if a chemist must decide business strategies for a company, they will probably feel unprepared to do so if it is a field that they have not specialised in.

If the problem is not familiar to the solver, interpreting instructions—that is, translating an abstract representation of a task into specific actions—occurs during the define phase, the earliest stage in problem-solving (Robertson, 2016). Specific problem-solving skills can be developed from that point on, since the more that the same type of problem is practised, the more automatic it becomes (Stocco et al., 2012). Shortening this process is incredibly efficient for potential future applications, because the solver stops relying on voluntary access to mental task representations and therefore spends less time on understanding its structure and finding the best path to approach it.

In cognitive science, mental representation often encompasses the objective problem space—that is, both the initial stage and the goal that are defined by the intermediate stages (Unterrainer & Owen, 2006)—as well as the subjective problem space, since the objective scope

usually remains incomplete. Therefore, comprehension within cognitive psychology remains as the process of constructing internal representations (Schnotz & Bannert, 2003). Looking for information through the problem space requires that the solver evaluates the effectiveness of the operators and applies the ones that they feel that would fit the problem the most. All this is performed within one's own representation of the problem and is affected by the environment that they find themselves in, which usually requires inductive inference.

While inference is described as the creation of new mental representations based on previously held representations—such as building up one's expectations about perception, or making plans through personal beliefs and preferences—applying reasoning to problem-solving goes beyond general inference. Within these scenarios, it refers to a specific form of inference at a conceptual level, “where not only is a new mental representation (or conclusion) consciously produced, but the previously held representations (or premises) that warrant it are also consciously entertained” (Mercier & Sperber, 2011: p. 57). In other words, inference might be an advantage for a new problem if applied correctly, but it can also modify and improve past knowledge when producing a brand-new representation.

This representation starts from the moment that a particular problem is introduced, even while an individual is still trying to untangle the nature of it. Upon grasping the first bits of information, the brain already begins cross-referencing all the data that is available to the solver along with prior knowledge or past experiences that might be useful for the situation. This process hopes to establish potential patterns or correlations that have already been encountered before to reduce steps to the minimum and allow an earlier or more nuanced understanding of it (Clark, 2013). For instance, there are some geometrical figures that can be inferred by reading a function because there are certain formulas that are associated with them, such as the scheme $(x-a)^2 + (y-b)^2 + (z-c)^2 = r^2$ for spheres. By predicting what type of space one is dealing with, one can already think about some formulas that cannot be applied and save time in doing so. Hence, stating the problem is crucial for the solver to grasp the strategy

that would be the most adequate to follow, as there might be an identical underlying structure to a previous situation that they have encountered, even if they differ in surface features (Robertson, 2016).

This representation is a model that is built by the solver when they have enough information and/or tools to approach its complexity which must include both the initial state of said problem as well as the desired goal state (Bassok & Novick, 2012). This brain image is a summary of what they understand about the components that they have been introduced to and the operators that they might use or rule out in order to reach the desired stage. There are numerous external factors that might influence how people understand a problem and therefore amplify, reduce or even bias the generation of solutions—e.g, visual perception constrained or accompanied by subjective experience as stated in Gestalt psychology. Still an influential movement nowadays, the main requirement of problem-solving according to Gestalt psychology is considered to be finding the right representation of the problem as opposed to finding the right way through a complex problem space as psychology of information-processing would suggest (Schnotz et al., 2010).

This space is represented by all sets of potential states that can arise while working a problem through and by the total amount of connections between said locations for the operations that enable the transfer from one state into another. In other words, it involves both the actions taken and the connections formed when transitioning between each step. For this to happen, the problem solver must count with a few prerequisites, the first one being an initial representation of what they have at their disposal. Likewise, they ought to be able to set up a space momentarily of the problem in question so that it enables them to develop a relatively specific idea about the goal state. Lastly, the problem solver should have enough knowledge over some operators that they can actually use to attempt to transform said problem stepwise into one or multiple intermediate states that are needed to reach the goal state (Schnotz et al., 2010). Reducing steps towards this state is called heuristics.

Heuristics, also called hill climbing, means-end analysis or avoidance of loops (Schnotz et al., 2010), helps to decide what the best next step might

be when encountering multiple possibilities to solve a problem space. The solver searches for an answer through a series of shortcut strategies, in which they might avoid an unnecessarily long process. As opposed to algorithms, which guarantee finding a correct solution, an exhaustive human search might end up being time-consuming and often impractical. A basic algorithm consists of examining all possible methods, which ensures a solution, but may be inefficient and unsophisticated. Algorithms are thus often used by computer programs, which have the capacity to process all possible solutions, but are also crucial for human problem solvers, since they differ from those directed to machines due to their limited memory capacity (Hinz et al., 2018). The algorithm for attaching a mirror on the wall, for instance, would usually require: a vertical wall that the object can be attached to; a position so that it stands half as tall as the person that will use it; and that the upper edge of the mirror is mounted at a height equal to the user's eye level and half the distance to the top of their head. If the mirror must be hung for a group of people as opposed to an individual, then the tallest person determines the top edge of the mirror, which must reach the halfway point of the person with the lowest eye level at the bottom (Herrmann, 2012).

Establishing key variables and dependencies (including all parameters) within the information that one is presented provides a more comprehensive look to the problem, which might shed light to discover the existence of alternative pathways to it (Eisner, 2021). In doing so, having categorised the problem might help to grasp as much as possible about the nature of the relationship between its components. Problem categories generally allude to the steps to take depending on the set of features that they exhibit as well as the relationships between these characteristics. Those relationships being a two-way street mean that, in turn, they tend to relate to or be determined by what the solver has to do (Robertson, 2016).

Even then, there are potential risks when undertaking a problem-solving task: successfully using existing knowledge becomes a positive transfer, but past experiences can also make it harder or ultimately impede the acquisition of new knowledge (Robertson, 2016). While the benefits of

previous experiences are significant, this does not mean that the result will be virtually error-free. Hence, it is recommended to keep double-checking an answer to make sure that it is indeed the right one. Knowing to assemble a wooden wardrobe might save time when trying to build a bamboo table, since they usually require the same tools and follow similar steps: nevertheless, assembling the second table in a different country where those tools are not available to purchase might require to go back to square one to learn how to assemble it in another way.

The *Einstellung*⁶⁵ effect was named after psychologist Abraham S. Luchins and mathematician Edith Hirsch Luchins in the 20th century as the mental state that the solver is stuck in where alternative—and often easier—routes to a problem remain unexplored due to the application of previous problem-solving procedures.⁶⁶ In other words, the same rule learning ability that makes an otherwise complex problem easy activates a mental set, which acts as a counterproductive programmed mental effect. Subjects in one of their experiments were given the well-known Luchins' Water Jars problem, which consisted in figuring out how to measure a specific amount of water using 3 water jars with different capacities to hold a fixed amount of water (Luchins, 1942). The order of the jars was rearranged, and minor variations of the same problem were proposed, hence the outcome also presented slightly different results depending on said variations.

Both groups were given four critical test problems to solve: whereas the experimental group was presented with five practice problems in advance, the control group was not. The warm-up problems that just half of the participants did involved using the formula $B - A - 2C$ (A, B and C being any 3 unknowns). Figure 8 shows problem 2 within the experiment, where there are three jars that can hold up to 21, 127 and three litres, respectively, and subjects had 2 ½ minutes to come up with an answer

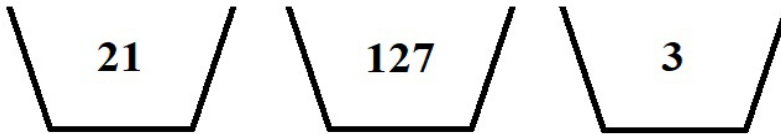
65. German term, which could be translated as “set attitude” (Author’s translation).

66. Abraham S. Luchins (1914–2005) and Edith Hirsch Luchins (1921–2002) were two mathematicians whose work involved the application of mathematical principles to Gestalt psychology, the Luchins’s Water Jars problem being their most well-known work (Luchins, 1942).

that made it possible to end up with 100 litres in the middle jar.

Figure 8

Representation of Luchins' Water Jars problem (Problem 2)



Upon conducting an experiment, it was found that the former group employed techniques that they had already used in the first set of problems, even though there were much simpler solutions. The solution was actually fairly simple, since once the 127-quart jar was filled, one just had to pour enough water for the 21-quart jar to be filled once and the 3-quart jar twice. Therefore, 100 quarts of water would remain in the middle jar. Even if there was a more effective response available, most participants opted out of it and applied a procedure that they already knew would work. One of the variations of this experiment included a new instruction at the beginning of the second exercise where subjects were told “not to be blind”, which helped some of them change the method that they were about to or had already mistakenly applied (Luchins, 1942). This shows the risks to inductive reasoning, which can result in the mechanisation of problem-solving and the hindrance of creativity. In other words, too much reproductive thinking can get in the way of productive thinking.

This process is known as negative transfer, where the application of previous knowledge prevents a sequence from being easier to complete, because the solver had already established a set of rules for a specific situation that is not necessarily related to the second one. Furthermore, expertise might lead solvers to navigate available information to reinforce their expectations rather than remain open-minded to novel ideas, thus adopting a dogmatic attitude in the process (Ottati et al., 2015). This view is also related to functional fixedness, when the solver is incapable of using an object for a novel purpose to solve a problem because it

is not the usual function of such an object. Some other factors such as induced stress have been also reported to negatively affect one's complex problem-solving ability (Wiley & Jarosz, 2012).

Expertise in problem-solving has been therefore defined as a combination of pre-existing capacities and processes as well as deliberate practice, the latter being the one that weighs the most (Robertson, 2016). Effortful adaptation as well as intensive training to the demands of a particular domain allow solvers to reevaluate and restructure their performance in order to acquire new methods and skills. Multiple factors influence success: motivations, predispositions, or even thinking styles such as focusing one's attention on the overall picture of a problem or considering all the details might also have an impact on one's performance. Similarly, individual performance in any task is determined by an amalgam of cultural, social and contextual factors that interact with motivational, personality and physical factors and determine the final result (Robertson, 2016).

In the Simon-Newell model, it is assumed that humans operate as an information-processing system (Newell & Simon, 1972). The task environment greatly influences the behaviour of the solver, no matter how the internal structure of their information processing system is configured (Newell & Simon, 1972). A problem is defined by a set of potential solutions, arranged according to a preference hierarchy, often represented in a structured format like sequences of algebraically encoded steps for chess problems. A problem-solver explores those sequences within the solution space that they encounter, using domain-specific knowledge as well as heuristics that allow them to pick a starting point and navigate through the course that they have selected. The problem is only considered to be solved once the candidate finds an answer that satisfies the constraints of the situation that they have been presented with.

Individuals discover new techniques by trying out different moves on a problem's configuration and figuring out which one works the best. They are provided with local constraints on the generation of moves in specific circumstances if they know tactical strategies, thus determining the tactic

that grants the best progress towards solution is key to create an optimal sequence of moves (Lee & Johnson-Laird, 2013). These constraints are the cause for goal blocking, and they range from unexpected environmental constraints such as bad weather to those imposed by the solver's abilities, or even the problem itself, like not having enough money to pay the rent (Robertson, 2016). Making mistakes within problem-solving, however, can be seen as a useful source of information that might prevent an even messier situation.

In every scientific hypothesis, but also in everyday situations by trial and error processes, mistakes are bound to happen. Hence, having room for error when choosing a solution is preferable to a one-chance scenario. If the hypothesis fails, one must trace back their steps and re-evaluate the situation, which will hopefully lead to a better alternative that should have been implemented in the first place. On some occasions, multiple methods might even be tested before choosing a definite one. Therefore, there are as many states within the problem-solving process as can be produced by the application of operators (Unterrainer & Owen, 2006).

Trial and error was more restrictive in mathematics and pedagogy before the Victorian period, but scientific psychology and evolutionary biology gave a new meaning to the phrase, becoming both a theory of learning and an account of transmutation in the process. Prior to the intervention of those fields, the term emerged for the first time during the 18th century as a mathematical tool. It acted as a synonym for an ancient arithmetic approach for solving an equation with one unknown called the "Rule of Position", the "Rule of False Position", or simply *regula fasi* (Cowles, 2015).⁶⁷ In the 21st century, with organisational dynamics changing on a daily basis, the solver is sometimes required to go beyond old methods when embarking on their quest for solutions and identify new issues that could eventually emerge from each potential solution (Marquart & Yeo, 2012). Globalisation and digitalisation as a result of the industrial revolution 4.0 has caused increasingly complex environments,

67. In mathematics, *regula falsi* is a method for solving an equation with one unknown by applying a trial-and-error technique of using test (the so-called 'false') values for the variable and adjusting the test value according to the result (Katz, 1998).

which offer wider possibilities to individuals, but also require enough skills to solve more complex problems both in personal life and at the workplace (Fischer et al., 2012).

Complex Problem-Solving (CPS) is slightly different from simple problem-solving because the exact features of the problem are unknown to the problem solver at the beginning and are subject to change over time (Funke, 2012). Additionally, it goes beyond reasoning because it demands interaction with the task environment (Wüstenberg et al., 2012). Said complexity is determined by multiple factors, such as the amount of information that is needed to solve it or how frequent it is as well as the environment in which it emerges (Meyer & Scholl, 2009). Among some of its categories, adaptative problems and goal-attainment problems demand working under pressure and improvising or selecting the goals for someone or something's needs, respectively. Goal-directed behaviour might improve CPS skills, the long sequences of which are positive towards the tasks but not necessarily pivotal to overall performance (Eichmann et al., 2020).

The difficulty of a problem—for a specific solver—is determined in many ways, regardless of whether a solution is attained or not: the number of steps that must be taken, the time that is required to find a solution, the quality of the solution, and so on. The basic structure of any problem is disjunctive, and a new method may be attempted if the previous one does not match the desired solution, each one having a different percentage of chance of solving the problem (Newell & Simon, 1972: p. 93):

$$\text{Probability of solution} = 1 - [1 - \text{probability}(\text{method})]^N$$

$$\text{Time-to-solution} = \text{setup-time} + N(\text{selection-time} + \text{execution-time})$$

N refers to the number of methods that have been attempted before reaching a conclusive solution. The success of the methods is not necessarily dependent on each other, and the process might be sped up by different factors such as previous experience, luck—think, for instance, about someone who is browsing through a few books in hopes of finding a theorem and they happen to encounter the right formula in the first book that they take from a shelf—or even improvisation.

Improvising is one of the multiple situations that require a central component to problem-solving: creativity. Viewing creativity as directed inwards facilitates the creation of innovative ideas and novel associations in memory (Beaty et al., 2016). This component is one of the hardest to measure as it largely depends on previous experiences, interests, opportunities, resources, the environment or personality traits (Guo et al., 2023). Some of the attempts to calculate creativity include the Moss Metric, which assigns a value to a product's creative component from 0 to 9 by multiplying the scores for novelty (or unusualness, determined by the inverse probability that an idea emerges within a homogeneous set of solutions) and usefulness (Chulvi et al., 2020). This method is widely used and accepted within the scientific community and can also be applied to problem-solving.

Most problems might share the same main mental processes for the most part, even if there is a clear distinction between creative and analytical problem-solving in the sense that the answer to the former usually requires remote associations or restructuring a completely original approach (Wiley & Jarosz, 2012). Attentional focus as measured by Working Memory Capacity (WMC) also varies, as creative problem-solving relies more on non-goal directed associative processes and analytical solving benefits the most from controlled, attention-demanding processes. There is a consensus, however, that most problem-solving in real life demands a mix of both, as of convergent and divergent thinking: rather than two opposite ends of the spectrum, these components should be seen as two ends of a continuum (Eysenck, 2003; Smallwood & Schooler, 2006).

Problem-solving can be acquired through multiple methods from an early age, one of them being Problem-Based Learning (PBL). PBL is a constructivist approach where students are required to solve an open-ended question in a team, so that they acquire problem-solving as well as teamwork skills by going from reflective observation and abstract conceptualisation to active experimentation (Robertson, 2016). From a concrete experience such as driving a snowmobile for the first time, the instructions that a person is given are modified by the process of learning, changing their strategy based on what they are doing right or wrong, e.g.,

remembering when you hit the brakes too soon and got 20 stitches in the hospital room, and waiting longer next time.

Whereas most educators regard problem-solving as a critical skill for life, there is yet no consensus on how and when problem-solving should be taught in educational institutions and the workplace, one of the reasons being that it is an extremely complex cognitive process about which little is known (Van Merriënboer, 2013). There seems to be a common understanding that it is required in later stages in life, as evidenced by how often it appears as essential criteria for job posts; there is little agreement, however, regarding how to approach problem-solving as an educational method, which often ends up in an absence of teaching altogether. The integration of higher order thinking skills that correspond to today's societal needs must be included as a pivotal component in educational curricula to provide students with enough problem-solving competences that they can apply in the real world to potentially help solving current and future issues (Sonnleitner et al., 2013).

3.3. Problem-Solving Skills Through Brain Dynamics

In order to fully understand how problem-solving goes beyond being an abstract skill to having an actual positive effect on the brain, it must be analysed from a neurological perspective, so that it can be developed in the most efficient way.⁶⁸ Moreover, the study and further comprehension of different types of neurocognitive processing enables the deciphering of the complex and non-fixed nature of the brain: it enlightens the similarities and dissimilarities in both learning and potential skill development (Otero, 2015).

Contrary to popular belief, these processes are relevant throughout all fields because they are intrinsically related with the ability to think and reason. Similarly, they are associated with pivotal components

68. On top of all the bibliographic research that has been carried out for this section, some information was provided by meetings with professors Conrado Antonio Fernández Rodríguez and Joaquín Escudero Torrella from the Faculty of Medicine and Dentistry at the Universitat de València, Spain.

within problem-solving such as focus, long-term memory, grasping knowledge and categorising it, finding patterns, and the implementation of the information that a person has formerly stored. While many questions remain unanswered to this day, there have been some achievements in several areas of research in the latest years that have made it possible to relate specific properties of brain networks to cognitive functions. These include the direct observation and manipulation of memory sequences or the identification of the synapses in the amygdala and basal ganglia where conditioning occurs (Lisman, 2015).⁶⁹ Though information about this organ has been obtained through various approaches, ranging from the cellular to the cognitive, integrating this data has been as complex a process as the brain itself.

Problem-solving encompasses a variety of these cognitive processes such as reading, accessing and interpreting semantic information or relating concepts one to another based on episodic memories which are activated depending on the problem type (Robertson, 2016). One way of simplifying the brain is dividing it into the same three levels of processing that a machine would undergo: defining and categorising the abstract properties of a mapping of information; choosing the algorithms that cover how this information can be implemented; and physically executing this algorithm through neurons and their network connections (Marr & Ullman, 2010). While these processes might indeed vary, multiple types of problem-solving share a common frontoparietal network when constructing a problem representation, looking for solutions or implementing and monitoring the efficiency of a solution, sharing a common neural correlate and thus similar mental processes (Lin et al., 2021).

The Victorian Era was an especially fruitful time for the study of the nervous system, since the brain was established as the organ of the mind during this period: neurology as an independent medical field, however, was not consolidated in the UK after WWI (Stiles, 2018). The

69. A synapse refers to “the site of transmission of electric nerve impulses between two nerve cells (neurons) or between a neuron and a gland or muscle cell (effector)” (*Britannica*, 2023e), while conditioning is a set of intelligent survival mechanisms supported by our neurobiological system.

discoveries of the sensor and motor functions of the spinal nerves by Charles Bell in 1811 and François Magendie in 1822, respectively; the location of the motor cortex during the 1870s; David Ferrier's cerebral maps in *The Functions of the Brain* (1876); and Cajal's neuron doctrine (1889) are among the most groundbreaking advances of the emergence of neurology—and thus neurolinguistics—as a potential academic discipline. The mid- and late 19th century ushered cerebral localisation research to try to spot which specific regions of the brain were responsible for certain mental processes: intellectual abilities such as problem-solving and emotional responses were among the answers that they looked for the most. Scientific research has enabled a higher nuanced explanation for some of these phenomena, while still being unsure of the function of others (Lisman, 2015).

As per what is known at the time of this thesis, the human brain is an extremely dynamic organ that determines a person's death—rather than the heart, the stopping of which might not be definitive—and its parts are equally complex to grasp, especially due to the number of interactions between them (Kumar et al., 2013). It is made of nerve cells which are responsible for transmitting and processing the information received from human senses, which sometimes remain unreliable, but enable a framework that the brain can work with without being too overwhelmed. The basal ganglia, for instance, performs basic motor functions; the limbic system integrates the emotions and sensations; the diencephalon encompasses the sensory and hormonal integration; the brainstem helps with automatic tasks by sending messages to the body to regulate balance, breathing or heart rate (Clarke, 2022). There are many parts that the human brain shares with many animals, such as the limbic system, the cerebellum or the nuclei of the basal ganglia: the cerebral cortex, however, is almost unique to humans—except for some primates like chimpanzees. While other regions of the brain allow the performance of motor tasks including movement, interaction with other people or adaptation to different situations, higher cortical functions necessarily involve the cerebral cortex (Huttenlocher, 2002). It is precisely through these more complex functions that awareness of one's existence,

reasoning or language are encompassed.

Although contemporary techniques and ongoing research have shed light on much brain activity, there is still so little that is known about this organ. As for now, getting an understanding of how the undamaged brain works is possible by looking at the effects of a damaged brain (Robertson, 2016). Rational and empirical justification remains the widely accepted method when researching and hopefully expanding knowledge—that is, universal laws or physical proof that support the veracity of a statement—, but there is not enough proof to fully grasp how all the aspects of the brain are related. Hence, the focus of science has traditionally shifted to the multiple ways in which problems can be approached rather than the steps that these take within the brain or the number of problems that are solved (Ruelle, 2007). It seems, however, that there is a relative consensus on the distribution of main and supporting areas when enduring specific activities.

The lateralisation of brain function is the tendency for some neural functions or cognitive processes to be specialised to one side of the brain or the other (Hwang et al., 2022). This organ consists of two main hemispheres—the right and the left one—, which are generally associated with specific abilities that humans have. In recent years, the left hemisphere is said to be the dominant one, which is responsible for conscious and reasoned tasks such as reading, writing, calculus, verbal memory or decision-making. The meaning and interpretation of language is also performed by this hemisphere, while the prosody of language—e.g., body language, tone of voice—is gathered by the right hemisphere. The latter performs intuitive tasks such as face recognition or music taste (Clarke, 2022).

While some regions of the brain are associated with certain tasks, that does not mean that they are the only ones who carry out said task, while the other ones momentarily switch off. Very much like fields of knowledge, brain activity is a holistic concept rather than a strict division into disconnected parts. Babies are born with a complete set of neurons, yet these get modified throughout the years through a neural process called synapse, which enables the transmission of nervous impulses from

one neuron to another, among many other functions (Tierney & Nelson, 2009). Therefore, when a neuron dies, it generally cannot be recovered, since the brain cannot regenerate its own neurons as opposed to other parts of the body like the skin. Like any rule, there are a few exceptions (So et al., 2015): some very specific areas like the hippocampus do divide neurons. Hence, if one specific region is ever deteriorated, the rest will try to replace the functions that are lacking: the more that these are developed, the higher the chances are for a better substitution.

Much progress regarding the connections between mental processes in health-risk situations goes through different fields of neurological research such as cognitive neuropsychology, which is the scientific field that uses the information granted by patients that suffer from brain injuries in order to “know the neural circuits that underlie different cognitive processes better” (Alonso & Fuentes, 2001: p. 569).⁷⁰ A key term within this cognitive activity is “dissociation”: this means that, after a brain injury, there is at least one function (X) that is deteriorated while another one(s) (Y) remains intact. This process implies that two mental skills are dissociated because they rely at least partially on two different neural systems. If one of the key regions within a skill worsens, the other regions, both main and support, will try to compensate said lack.

Except for in a few very specific cases—for instance, that X and Y employ the same neural circuits, but that X’s is a simpler version and therefore said activity is not affected by the deterioration of X—cognitive neuropsychology can provide a full explanation on brain organisation (Alonso & Fuentes, 2001). Additionally, the existence of a cognitive reserve as the “capital of knowledge and experiences that an individual acquires over their life-span” (Arcara et al, 2017) is intrinsically associated with brain reserve—that is, the ability of the brain to cope with neural damage (Raskin, 2011). Hence, intelligence can be trained, and it can become significantly powerful to survive serious brain damage in extreme situations.

There are a series of steps involved in problem-solving from a

70. Author’s translation.

neurological perspective (Ruelle, 2007; Robertson, 2016): a first stage when one gathers data and familiarises themselves with the topic (the preparation period), and might come up with a solution, or fail to provide a correct answer; the incubation period, where someone might sleep on the problem or even forget it until they reach stage 3, illumination, where they suddenly think about it again, probably influenced by a conversation or something that they associate with it; and verification, when a hypothesis is confirmed or not. The incubation period is said to be combinatorial in nature (Ruelle, 2007) since several ideas are combined in various ways until the right one is thought to be found. The different parts of a problem are later sent to the frontal lobe, which is the region that plans and decides whether to do something or not. If the brain understands the problem, the frontal lobe is also responsible for establishing relationships between concepts and ideas. Motivation and interest are also located in the frontal lobe, which are key, along with innate characteristics related to genetics and the environment, to solve more sophisticated problems.

While sophisticated reasoning is mostly associated with the left hemisphere, the right hemisphere also plays a role in processes like deduction or induction (Martín-Salguero et al., 2023). When confronted by a deductive reasoning problem, the human brain engages with linguistic and reasoning networks that eventually converge into a supramodal, language-independent reasoning network. Said connections are temporarily dynamic due to the fact that distinct brain regions are involved at different degrees during the stages of reasoning (Rodríguez-Moreno & Hirsch, 2009). Likewise, memory, like remembering faces, gets to the brain through the hippocampus, which a structure embedded into the temporal lobe, but it is not known yet how or where exactly it is stored within the brain (presumably, in many regions).

Exponentially developing one skill sometimes can have countereffects, like famous Alexander Luria's case Solomon Shereshevsky (in Russian Соломон Вениаминович Шерешевский), a patient that remembered every single thing that he had ever experienced but presented cognitive deficiencies and difficulties to conceive the world in abstract terms (Luria,

1987). His exceptional episodic memory and mental operations bore a strong resemblance to some well-known mnemonic devices such as the method of Loci (Johnson, 2017). In this method, an imagined physical space is used to organise information and provide an extraordinary amount of detail, although Luria suggested that these came later and merely complemented his natural ability.

Precisely because some regions within the brain might become a support but are never switched off, the conventional separate types of thinking as traditionally considered by the multiple intelligence theory in *Frames of Mind: The Theory of Multiple Intelligences* (1983) by psychologist Howard Gardner (Stenberg, 2015) are therefore not completely independent from each other.⁷¹ While problem-solving is often more associated with logical-mathematical thinking, a term which is used throughout this chapter for clarity purposes, this does not imply that these skills are limited to this type of thinking, but rather that problem-solving comprises multiple types of reasoning. While it remains unknown to what extent or how exactly one's own consciousness develops, it is proved that it is the result of numerous cells connected to each other (Blumenfeld, 2015). This is also how knowledge is represented in memory—and therefore fundamental for problem-solving.

Knowledge is represented in memory as an associative network of nodes that are interconnected by links, which deeply influences the accuracy and efficiency with which prior knowledge can be activated and employed as a framework for the integration of new available data (Wetzels et al., 2010). Each node embodies a concept, which are important units of knowledge, and the links establish the relations between them and organise their meanings. Whenever new information is apprehended, the

71. These are: logical-mathematical thinking, verbal-linguistic intelligence, spatial-visual intelligence, musical intelligence, bodily-kinesthetic intelligence, intrapersonal intelligence, interpersonal intelligence and naturalistic intelligence. Since the definition of intelligence is subjective and ever-changing, such a differentiation seems too narrow and simple, and leaves critical skills such as emotional intelligence out. For clarity purposes, logical-mathematical thinking is employed instead as it also focuses on areas that are related to logic, abstractions, reasoning, numbers and critical thinking, but does not limit intelligence to eight types.

connections are strengthened, and new connections emerge. To some extent, predictability from this system can be drawn—and yet detailed storing of information escapes human comprehension.

Even though the brain can be seen as a predictive system—for instance, it can be fooled into thinking that a person is partially blind by covering one eye or projecting things that are not there under certain circumstances—, interpreting how the brain monitors and coordinates itself based on electroencephalographic (EEG) dynamics would be incomplete due to the traditional lineal nature of said recordings. Envisioning the brain as a chaotic or quasi-chaotic system may endure a higher complexity, but becomes a more realistic representation of the way the organ works. Hence, the hypothesis that the rate of chaos and order that emerge when performing specific functions varies depending on the difficulty of the cognitive task has been confirmed through non-linear analysis of the EEG by employing fractal modelling and chaos theory (Hernán Díaz et al., 2015).

Due to the latest advancements of imaging techniques, the accuracy about the nervous system—and therefore the effects that skills such as problem-solving have on the brain—has experienced a rapid expansion of knowledge. Now, there are some technologies that can aim at small areas within the central nervous system (Lisman, 2015). The highest precision in humans that currently exists is achieved by invasive methods, such as the implementation of stimulators which use low electric currents to stimulate groups of neurons and that are directly connected to the targeted areas with electrodes. Nevertheless, there are other non-invasive methods that influence neuronal activity by altering the firing thresholds of underlying brain tissue such as those that include a magnetic field (TMS), or ultrasound (Transcranial Focused Ultrasound Stimulation [tFUS]), among others.

The main innovations in the field are the invention of Magnetic Resonance Imaging (MRI), functional Magnetic Resonance Imaging (fMRI) and Positron Emission Tomography (PET) scans, which have enabled the 21st-century scientific community to pinpoint areas of the brain involved in even the most complex mental processes such as

problem-solving with much greater precision (Ventura-Campos et al., 2022). When compared to other functional brain imaging resources, these non-invasive techniques are particularly advantageous due to their high spatial and temporal resolution, which allow the measurement of brain activity indirectly by means of changes in the blood oxygen level as opposed to a rather unpleasant and sometimes undoable experience for the patient (Unterrainer & Owen, 2006).

It is precisely the dynamic nature of brain network organisation that requires knowledge of underlying neurophysiological mechanisms (Medaglia et al., 2015). For instance, the frontal lobe remains one of the greatest mysteries within the brain. This region is essential for decision-making and planning (Clarke, 2022), although the way it works is still not completely mastered. There was a famous patient within the neurological field in the 19th century, Phineas Gage, who surprisingly survived a serious work accident after a large iron rod was driven through his head. The medical report of his recovery stated that the iron rod had entered the left side of his face in an upward direction as he opened his mouth and completely out the top of the skull (Harlow, [1999] 1848). His left frontal lobe was destroyed, and he behaved like a completely different person for the rest of his life. He did not plan ahead for events, had a hard time choosing and was irreverent and showed little deference towards his co-workers—which was reported to be very unlike him to do—, making him “a living part of the medical folklore” (Ratiu et al, 2004: p. 642). Such a medical phenomenon implies that the frontal lobe is key for reasoning and problem-solving.

The angular gyrus (AG) is also associated with a number of cognitive functions including (a) aspects of memory, (b) the retrieval of numbers and visuospatial facts in calculations, (c) the processing of abstract concepts and (d) the orientation of the attentional system to the most important information (Robertson, 2016). In other words, the brain starts to work more intensely through the connection between premises, or potential approaches to solve them where they were given two pieces of information that they could compare and contrast rather than anticipating the second premise (Rodríguez-Moreno & Hirsch, 2009).

Not all frontal sub-regions engage equally in elementary reasoning. As opposed to the right lateral cortex, which is neither necessary for inductive reasoning tasks (Reverberi et al, 2005) nor for elementary deduction, the medial prefrontal as well as the left lateral prefrontal cortex are also heavily involved in problem-solving. Measuring reasoning is key to understand problem-solving since it performs in the same way within the brain: it is a skill that is activated when encountering a conflict—like two premises—that have no evident solution. Since a problem requires different types of knowledge depending on its constraints, it is only natural that the main area that endures said activity may vary as well. Some might activate creativity and intuition, while others stick to a logical-mathematical approach that relies on the left side for the most part (Clarke, 2022). Be it a more unbalanced or equitable distribution, they will both take part in the process, vacillating over various levels of complexity within sophisticated reasoning.

All mental processes that are used by individuals for deriving new information out of given information are defined, whether that is with in regard to problem-solving, decision-making or planning actions (Knauff & Wolf, 2010). Furthermore, what distinguishes such complex cognition from regular cognition is that it occurs under complex conditions where a multitude of cognitive processes must interact with one another or even with other noncognitive processes. The caudate nucleus, for instance, is involved in transmitting information between brain areas when there has been no previously established pathways. It helps to integrate the various sources of information when encoded instructions need to be transformed into actual behaviour. Similarly, some cortical regions seem to control interference from irrelevant stimuli (Stocco et al., 2012).

When comparing word versus number problems, the former have been considered to be harder to solve than the latter (Daroczy et al., 2015). Linguistics largely depend on the recipient's ability to learn and repeat as well as to understand the question (3x3) and provide the correct answer from their own memory, the activation of the left angular gyrus being higher when developing language comprehension and arithmetic (Klados et al., 2013). This is when Wernicke's area is activated, another part of

the cerebral cortex that is linked to speech and sophisticated intellectual functions. Thus, these two pairs of processes are handled differently by the brain but are both primarily located in the left hemisphere (Clarke, 2022). Error rate and reaction time effects were also found to be correlated with individuals' reading span, which suggests that performance relies on working memory capacity to a certain extent.

As mentioned earlier in the chapter, Working Memory Capacity (WMC) stands for “the capacity to selectively maintain and manipulate goal-relevant information without getting distracted by irrelevant information over short intervals” (Jha et al., 2014: p. 348). Problem-solving depends on said capacity by helping the interpretation of problem statements and overlooking irrelevant information within the problem so that it can be turned into an accurate mental representation. In other words, the probability that previous learning will be transferred from one context to another relies on whether the representation of the target is formed in short-term working memory and the source in long-term memory (Robertson, 2016). Furthermore, WMC might play a role regarding the ability to successfully retrieve math facts as well as temporarily store initial information and partial results from long-term memory (Wiley & Jarosz, 2012).

Working memory may be fundamentally strengthened and efficiently organised by greater frontoparietal network (FPN) cohesiveness and visual interactions (Palva et al., 2010), both at rest and during performance. The former is also central when supporting complex control functions along with the cingulo-opercular system (Cocchi et al., 2013). If the generation of this initial representation happens to be inadequate for the specific situation, then the solver is likely to reach a dead end—an impasse. An impasse stands for “a state of mind in which the problem solvers become stuck and have no idea of what to do next after all options have been explored” (Qiu et al., 2008: p. 101), an invisible mental wall that the solver does not seem to be able to overcome. If a goal-achieving action cannot be performed due to a missing precondition, achieving said precondition becomes the next system subgoal, and this chain reaction continues until the desired result is reached (Donnarumma et al., 2016).

Upon facing a problem, some elements within the task environment might unconsciously trigger the retrieval of elements from long-term memory that appear relevant to the new task (Robertson, 2016). Though supported by the rest of regions, the primary focus of problem-solving—and therefore cognitive processes including learning, reasoning, applying creativity and decision-making—takes place in the prefrontal cortex (PFC). An explosion of gamma wave oscillation activity of around 500 m/s⁷² occurs right before someone claims to have finished with a solution to a problem, which explains why most people are interested in solving puzzles, reading murder mysteries, creating inventions, or doing research (Oh et al., 2020).

Though there is still a long way to fully grasp how problem-solving interacts within the brain, there is evidence as shown throughout this section that (a) it involves multiple parts of the organ which can be developed depending on the type of problem that the solver is presented with; (b) it has positive effects including the application of strategies from a previous experience to a new one; and (c) it can also increase the chances of someone recovering from serious brain damage. Most importantly, working on building these skills can save life-threatening situations—such as a Global Citizenship for current worldwide crises.

3.4. Problem-Solving Applied to Global Citizenship

Not only can problem-solving skills be acquired *from* different disciplines—including literature—, but it can also be applied *to* different fields. While seemingly unrelated, building upon these abilities through the unravelling of enigmas can have a direct effect on major issues. They are directly associated with reasoning and neuroplasticity—that is, the brain adapting and changing in response to novel experiences (De Oliveira, 2020). In other words, they prove to be useful when it comes to strengthening relationships or encouraging healthy communication in

72. M/S stands for the number of meters per second to state the distance between an oscillating objects natural position and its maximum displacement during an oscillation (Physics Education Research Group, Kansas State University).

the workplace, but also become extremely beneficial on a cognitive level. Problem-solving skills are transferable, so they can be developed through various means and later applied to real-life situations. While these skills have numerous applications, the current emergency situations that the world is going through requires a very specific one: a Global Citizenship for the 17 Sustainable Development Goals (SDGs) by the United Nations.

According to the United Nations website, “promoting global citizenship in sustainable development will allow individuals to embrace their social responsibility to act for the benefit of all societies, not just their own” (n.d.). In other words, being a global citizen means acknowledging that people are not single actors, but rather that they have an active role and responsibilities to the world. This mindset is integral to the 17 SDGs, which emerged as a further extension of the Millennium Development Goals (United Nations, 2000).⁷³ A significant amount of progress has been secured by this initiative by spreading global awareness as well as political accountability, though highly variable across countries and regions (Sachs, 2012). By the end of 2015, the Assembly reunited again to evaluate said advancements and to set up a new plan of action that would serve as a similar framework for the following 15 years.

As from January 1, 2016, the United Nations implemented the 2030 Agenda, in which they made an urgent call for all countries to cooperate on a social, economic and environmental level to further expand the previous objectives. While there have been some notable changes since 2000 (Matenga, 2022; Rybalkin et al., 2023), time is still running out to palliate climate change consequences and there are still many social-political critical situations such as global injustice and high levels of poverty throughout the globe that demand immediate and effective

73. The Millennium Development Goals were a set of eight international objectives that were meant to be completed from 2000 to 2015 as stated in the Resolution adopted by the General Assembly on September 18, 2000, titled 55/2. *United Nations Millennium Declaration*. These statements were summarised as the following points: (1) eradicate extreme poverty and hunger; (2) achieve universal primary education; (3) promote gender equality and empower women; (4) reduce child mortality; (5) improve maternal health; (6) combat HIV/AIDS, malaria and other diseases; (7) ensure environmental sustainability; and (8) global partnership for development.

measures (Perkins et al., 2022; Fulzele et al, 2022).

Figure 9

Sustainable Development Goals by the United Nations



The official SDGs by the United Nations (Figure 9) are the following: (1) no poverty; (2) zero hunger; (3) good health and well-being; (4) quality education; (5) gender equality; (6) clean water and sanitation; (7) affordable and clean energy; (8) decent work and economic growth; (9) industry, innovation and infrastructure; (10) reduced inequalities; (11) sustainable cities and communities; (12) responsible consumption and production; (13) climate action; (14) life below water; (15) life on land; (16) peace, justice, and strong institutions; and (17) partnerships for the goals (United Nations, 2015b). In this section, some of the potential unknowns that could be addressed through the application of problem-solving skills are outlined.

3.4.1. Goal 1. End Poverty in All its Forms Everywhere

While the term “poverty” is generally associated with hunger, this global issue is not restricted to food and water but rather encompasses the absence of basic services needed to ensure the right to live a decent life, including cultural poverty (UNESCO, 2023a). In other words, it is the lack of resources that are required to guarantee dignity and survival as opposed to reducing life expectancy and hindering people from reaching their full potential (Gill & Smith, 2021). The current scarce availability of housing, the limited or no access to healthcare or the few opportunities regarding education that might eventually lead to a lack of cultural knowledge are all part of the root of the problem that involves the perpetuation of poverty. If these levels continue, by 2030 more than 575 million people will be living in extreme poverty as stated by the *The Sustainable Development Goals Report 2023: Special Edition*. Despite the increase of social protection measures since the COVID-19 pandemic at the time of this doctoral thesis, many people in low-income countries do not receive any type of cash compensation from the government and remain unprotected to the multiple challenges that the poverty line endures (United Nations, 2023).

Progress on reducing national poverty—which varies from country to country depending on their economic and social conditions—has been slow and uneven (Sen, 2021). Such a complex situation requires research and problem-solving strategies that palliate deprivation across numerous dimensions, which governments need to address. According to the Intergovernmental Panel on Climate Change, a research body set up by the United Nations, climate-related risks on food security—and therefore poverty—are prone to increase under global warming, which might potentially cause notable reductions in cereal yields such as maize, rice and wheat throughout many regions of the world (IPCC, 2018). The most vulnerable to these consequences are usually the poorest ones and other marginalised groups (e.g., indigenous communities). To combat this effect, they become the strongest advocates of sustainable consumption, even if wealthier countries typically have the highest ecological footprint (Broad, 1994).

3.4.2. Goal 2. End Hunger, Achieve Food Security and Improved Nutrition and Promote Sustainable Agriculture

Malnutrition, measured as the lack of nutrients for the effective human development (United Nations, 2023), is a public health issue, and detrimental to mortal rates (Lobell et al., 2011). As the rest of the goals, food security is a complex issue that is influenced by national economies and regulations as well as politics and international relations, among many other internal and external factors. Increasing prices, shortage of products or no food and water resources might lead to an unhealthy diet. Early life malnutrition can result in lower bone mass in children and adolescents due to inadequate levels of adequate calcium, phosphorus, magnesium, and vitamin D (Boyanob, 2016). The current measures are insufficient, since nearly 924 million people (11.7% of the global population) in 2022 faced food insecurity at severe levels according to the *The State of Food Security and Nutrition in the World 2022 Report* by the Food and Agriculture Organization of the United Nations.

The distribution of supplies throughout is therefore an extremely complex issue to overcome and ensuring that everyone has access to basic services is an equal complex task. Among many approaches, evaluating a new system goes through Artificial Intelligence (AI), which could draw the existing relationships between the dynamics of hunger, healthcare, economic prosperity, and population indices. Overcoming food security hazards needs a paradigm shift in thinking, and therefore re-stating the problem to achieve potential solutions (How et al., 2023). AI requires investing in research, but also educating researchers to have enough problem-solving skills to prioritise some parameters as opposed to others so that any issue is overcome in the most efficient way possible.

3.4.3. Goal 3. Ensure Healthy Lives and Promote Well-Being for All at All Ages

The mobilisation and transport of pathogens due to storm runoff and floods and the subsequent displacement of populations can lead to potential exposure to inadequate sanitation infrastructures. Similarly,

the infiltration of seawater into drinking water distribution and sewage lines are some of the climatic hazards that affect exposure pathways for several different chemical risks, including those that are directly linked to carcinogenesis (Portier et al., 2010). Climate change is not limited to the ecosystem—already a threat to living beings—, but is also expected to have negative effects on the physical well-being and to further damage mental health indexes. Therefore, policies that go from strengthening public health systems to providing citizens with greater access to green and natural spaces are of paramount importance to promote healthy lives for all (Cissé et al., 2022).

Through an adaptive urban design that enhances biodiversity, air quality can be improved while reducing risks of potential respiratory illness or heat stress as well as diminish the impact on mental health due to congested urban living: the urban plan that many regions have, however, is far from adopting enough measures to turn urban areas into green cities (Wilby & Perry, 2006; Cissé et al., 2022). Be it due to economic resources, urban policies or lack of focus on ecological initiatives, problem-solving is needed to plan out a strategy that allows mobilisation whilst ensuring car-free spaces and encourage healthy diets that further prosperity.

3.4.4. Goal 4. Ensure Inclusive and Equitable Quality Education and Promote Lifelong Learning Opportunities for All

Current educational systems fail to present a holistic approach to the demands of a coordinated social learning process and therefore become essentially dysfunctional (Espinosa & Walker, 2011). With no social awareness, the chances of recognising one's privileges and their position in society are slim - hence, the need for a global citizenship. Likewise, developing critical thinking is not taught in school, but entails a set of steps that constitute one of the main parts of problem-solving. Education for Sustainable Development (ESD), defined by the United Nations Educational, Scientific and Cultural Organization (UNESCO) as integral for quality education, “empowers learners of all ages to make informed

decisions and take individual and collective action to change society and care for the planet” (UNESCO, 2023b).

ESD becomes a tool which is specifically designated for ensuring and promoting inclusivity while acquiring essential competences for daily life. Involving multiple disciplines, sustainability challenges are extremely complex and require a systemic and equally complex perspective of the issues that they encompass (Haba Osca & Castelló Cogollos, 2021). Not only is education the starting point for the shaping of core values such as respect, tolerance, and justice, but also the time to begin the acquisition of strategies that might be integrated by the time that they need to be applied in the students’ future. Being granted access to school is the first step, followed by a comprehensive formation that allows equal learning opportunities regardless of someone’s background, gender, race, religion, or sexual orientation—the solution to which does not exist yet. The acquisition of problem-solving applied to this goal contributes to the sense of global citizenship because it does not look for solutions for isolated individuals, but for opportunities for all.

3.4.5 Goal 5. Achieve Gender Equality and Empower All Women and Girls

While women have more access to education than in previous years, data shows that they still experience constant discrimination in every sphere in their lives, including in the domestic space—where they still perform most of housework—, in-between partnerships—where the numbers regarding emotional and physical abuse are alarming—or in the workplace, where the glass ceiling prevents them from achieving the same positions as their male counterparts (Duflo, 2012; Dang & Viet Nguyen, 2021; Elveren et al., 2022; United Nations, 2022a). Advancing toward the top of a hierarchical corporation has improved in the last 20 years, yet there are still multiple factors that prevent women from getting promoted to executive ranks. While men earn more and are invited to more interviews on average when getting married (McDonald, 2020), the active participation of women in the labour market drops when they do

as well as when they verbalise that they intend to have children in the near future (Correll et al., 2007; Kahn et al., 2014); while female CEOs are more likely to be appointed when the firm is in crisis, men show a higher percentage when the company had a solid performance (Glass & Cook, 2016).

Acquiring problem-solving means being able to approach and eventually eradicate gender inequality issues such as the gender-pay gap or the distribution of chores between women and men whilst understanding via critical thinking why empowering women is beneficial for everyone. In this sense, economic development and women empowerment become intrinsically interconnected (Duflo, 2012), hence the problem-solving strategies should be thought through for both.

3.4.6. Goal 6. Ensure Availability and Sustainable Management of Water and Sanitation for All

Like food, water is necessary for most living beings. This is especially true given the increasing extremes due to climate change—natural disasters such as floods or the rising storm activity, for instance—which have the potential to cause significant damage to such infrastructure. In some regions, where infrastructure is much more susceptible to damage and pollution, an adequate access, disposal and sanitation of water is not guaranteed: non-potable water can, therefore, cause health issues and severe illnesses that are hard to recover from (Schoen et al., 2018). In addition, melting and thawing of snow as well as ice and permafrost due to increasing temperatures have proved to have adverse effects on water quality, and health: likewise, biophysical processes in wetlands experience changes, influencing both the feeding and breeding habits and species' distribution ranges (Caretta et al., 2022). Deoxygenation in the lower depths of the water columns and the destabilisation of the entire water column is another consequence of heating, which provokes a chain reaction on water security.

Thus, better management of water resources and supply augmentation are some of the most effective adaptation strategies that must be developed

to protect source water and manage both water supply and demand, but the interventions of which require financial investments for the most part (Eakin et al., 2016). Poor-quality drinking water does not only affect low-income areas, which makes water sanitation a common issue: the lack of access to the poorest is therefore a contradiction that needs an urgent solution whilst ensuring that water sources are carefully employed.

3.4.7. Goal 7. Ensure Access to Affordable, Reliable, Sustainable and Modern Energy for All

Lessening the multiple dangers of climate change requires a rapid and efficient shift from non-renewable energies such as those derived from fossil-fuel energy to low-carbon systems (Healy & Barry, 2017). The overuse of nuclear power plants produce uranium mill tailings and other radioactive waste and are detrimental to living species, yet still make almost 10% of the total amount of energy that is consumed according to the *International Energy Agency Report* (IEA, 2023). The inadequate usage of this type of energies might limit the availability of other resources in the near and far future. Future projections therefore depend on bioenergy production based on clean technologies and new power-generated infrastructures that are regulated by green policies. Investing in renewable energies such as the solar, wind, geothermal or hydropower—that is, those derived from natural sources and systematically replenished—as well as its modern applications like solar panels; contributing to the rise of manufacturing and sales of electric vehicles: these measures have already been drawn and put into practice yet have not managed to achieve the desired low-impact energy levels (Sufiani et al., 2023).

Modifications within energy planning must also address inequalities in power across socio-energy systems, yet most energy regimes hardly ever incorporate this dimension into their policies (Miller & Richter, 2014). Rather than narrowly keeping social considerations to an economic sphere and exclusively focus on the relationship between energy prices and energy access and the general population, energy design currently

fails to acknowledge and take into account broader social and economic assemblages that both affect and are affected by their consequences—and that therefore become another layer of problems to solve. In short, a full transition to net-zero emissions demands measures like decarbonising all areas of energy production and using scientific knowledge to develop even better reductions of health-damaging energy waste.

3.4.8. Goal 8. Promote Sustained, Inclusive and Sustainable Economic Growth, Full and Productive Employment and Decent Work for All

In a world already undergoing dangerous climate change and other serious environmental ills, many people within the job market still struggle with precarious livelihood conditions: according to the current progress as stated by the United Nations (2023), there were around 2 billion workers around the world in 2022 under the status of informal employment—that is, precarious jobs which lack social security for the most part, 1 in 10 children being engaged in child labour worldwide. Multiple families depend on their agricultural income, the survival of plants, livestock and fish, which, when and if lost, become an economic and social catastrophe. These alarming indicators, which have only been further worsened by the pandemic (Mestdagh et al., 2023), require immediate but complex problem-solving regarding issues such as the creation of positions, equal pay for work of equal value, or the integration of the youth within the job market.

Agricultural loss or precarious labour conditions are also two of the multiple causes of migration. On the one hand, mitigation and adaptation processes can establish significant development opportunities, particularly regarding employment creation (Healy & Barry, 2017). On the other hand, forced displacement due to drought or other weather-induced events including natural disasters, or even internal migration from rural to urban areas, could be reduced. There needs to be a proportionate investment in eco-friendly job practices, especially when it comes to avoiding agricultural losses and ensuring social protection for all. When sustainable measures largely depend on a country's economy, inequality

is bound to happen, since not all nations have the same economic level to support the newest resources—thus, leading to ecological distribution conflicts (Martinez-Alier et al., 2016).

3.4.9. Goal 9. Build Resilient Infrastructure, Promote Inclusive and Sustainable Industrialization and Foster Innovation

Climate change is increasing and accelerating transitions from rural agricultural production into urban wages, but not in ideal conditions (Cai et al., 2016; Kaczan & Orgill-Meyer, 2020), and often resulting in regional disparities. Reusing biowaste in either agriculture or energy production and setting up resilient infrastructure that rural settings can benefit from may directly assist vulnerable communities while targeting sustainable industrialisation. Through the provision of inputs such as drip irrigation or water storage, these strategies can help to reduce both costs and pollution levels (Birkmann et al., 2022). They demand, however, innovative methods that allow the implantation of new ecologically oriented systems that use resources while preserving natural spaces.

As for now, fossil fuels, pyrolysis⁷⁴ and hydrothermal carbonisation (HTC) are among some of the emerging technologies that can turn residuals into value-added products such as biochar, a carbonaceous product from pyrolyzing biomass (Ducey et al., 2022). Similarly, combustion of hydrochar, a carbon-rich substance that becomes anaerobically produced in the presence of water at high pressure as well as temperature, has been proved to considerably decrease global warming potential compared to that of coal combustion (Berge et al., 2015). Potentially killing pathogens and antimicrobial resistance genes (ARGs) is pivotal to improve agriculture and industrial waste treatment systems. Many of the studies on these methods are notably recent and highlight the need for improved water management strategies within the HTC process to fully leverage HTC technology. Technological innovation relies on funds—which are not available to everyone—and scientific research—with solid problem-solving skills.

74. Pyrolysis is the heating of biomass in the absence of oxygen.

3.4.10. Goal 10. Reduce Inequality Within and Among Countries

Lack of accessible paths for disabled individuals or better conditions during migratory movements: these are among the concerns within Goal 10. The latter has dramatically increased in the latest years, involving both risks and potential opportunities for origin, transit, and destination countries (Sensi & Pedrotti, 2019). This phenomenon increases incoming people's vulnerability, as they are not in the same conditions as they are back home, let alone in the same ones as born citizens in the host country. Said conditions vary greatly depending on the destination country that they migrate to as well as their origin, along with some other factors such as the level of studies, the economic status or potential connections from past experiences that might help them to navigate the process with some expertise beforehand. The more migrations that are studied, the more intersections of age, gender, class, ethnicity and race that are found. These are believed to be important for the whole process as well as directly connected to the climate hazards and differential impacts and losses that affect the vulnerable, marginalised and low-income families in contemporary societies (Nyantakyi-Frimpong & Bezner-Kerr, 2015; Walker et al., 2021). Furthermore, the unequal distribution of resources when natural disasters occur or the lack of economic power to palliate global warming make the poorest communities even more vulnerable to the negative consequences of climate change.

If renewable energies and eco-friendly products cost more than the production of current technologies and there is no social law that encourages innovative techniques by covering the costs partially or completely, only leading economies can afford to implement green measures (Martinez-Alier et al., 2016). Thus, other countries and/or specific regions are kept waiting for an adequate investment that is proportional to their needs, risking their own quality of life to a greater or lesser extent. At the time of this thesis, the latest global healthcare emergency (SARS-CoV-2 virus) was viewed by some academics as the ultimate test for achieving the SDGs, and the potential groupwork between countries from the United Nations to ensure a fair distribution of all the vaccines (Aborode et al., 2021). During the pandemic, however,

not enough COVID-19 doses got to many countries, particularly within Africa, and many of those which did, were not employed for a long time (Massinga Loembé & Nkengasong, 2021). The inequitable access to medication is not the first time that occurs, as it did with H1N1 vaccine doses during the 2009 outbreak (Ankomah et al., 2022; Soulé, 2022). Given that these events took place just a few years ago, problem-solving techniques are required to ensure an improved distribution of basic services such as healthcare and education, regardless of countries' economic power.

3.4.11. Goal 11. Make Cities and Human Settlements Inclusive, Safe, Resilient and Sustainable

Due to the rural-urban migration pattern in the latest years, urbanisation is yet to be considered by the agro-food sector: while there is an urgent need to invest in rural areas by providing more jobs inside and outside of farm production, agriculture must also be encouraged in urban and peri-urban areas (Bombelli et al., 2019). Promoting self-productions and 0 km food, reserving and protecting space for agriculture within cities should be part of every architectural project that aims at adapting contemporary lifestyles with sustainable housing. By providing necessary and timely information to decision makers and stakeholders, the progress for this goal is monitored in order to make informed decisions to accelerate progress towards access for all to adequate, safe and affordable housing and basic services and upgrade slums.

The steady trend towards urbanisation will have an impact virtually in every facet of human lifestyle in the coming years, while for now these movements have influenced many people's quality of life as shown by the number of people living in slums worldwide (Takyi et al., 2021). The causes for the proliferation on slums vary, but are highly dependent on housing policies, urban densification, disasters or the lack of affordable housing: slum household is defined by the United Nations as "individuals living under the same roof lacking one or more of the following conditions" (UN-Habitat, 2018):

- Access to improved water: at least one facility or source that is protected from outside contamination such as piped water into dwelling
- Access to improved sanitation: facility with an excreta disposal system that hygienically separates human waste from human contact
- Access to sufficient living area: the same habitable room can be shared by a maximum of three people
- Access to housing durability: it must be built on a safe place as opposed to hazardous locations. Some examples are near toxic waste, on a steep slope or in a dangerous right of way of the highway or airport. Likewise, it must have a permanent and adequate structure that does not need major repair and is resistant to adverse climatic conditions such as torrential rain, extreme heat and cold, or humidity
- Access to security of tenure: should have a legal status against arbitrary unlawful eviction, harassment as well as any other threats. The housing structure should have statutory or customary law or informal or hybrid arrangements that safeguard the house members against forced evictions

Since this is where persistence of poverty remains a critical factor in major cities, one of the major challenges of urbanisation today is granting housing as well as upgrading slums and informal settlements (Corburn & Sverdlik, 2017). In addition, it is estimated that more than three billion people will need adequate housing over the next 15 years due to the rapid occupation of cities, including the development of slums that will require an effective management (Shekhar, 2020). The deprivation of the right to an adequate standard of living and housing to millions of people and therefore perpetuating their exclusion from the benefits of sustainable urbanisation are social and public health issues that need to be solved.

3.4.12. Goal 12. Ensure Sustainable Consumption and Production Patterns

Purchasing food that will not be consumed or transporting it unsafely results in approximately 10% to 20% of products harvested not reaching

retail markets, with tons of food ending up in landfills. These landfills are responsible for generating eight to 10% of global greenhouse gas emissions, according to the United Nations (2022b). There are multiple factors that contribute to unsustainable consumption patterns, the lack of ecological awareness and failures in the markets of recyclable materials being some of the major ones. On top of potential environmental consequences, spreading insufficient information when it comes to eco-friendly consumer practices and their potential benefits aid the active employment of fewer resources and the discouragement of circularity, which helps to minimise waste generation (Viaggi, 2021). Getting second-hand products or from local production, ensuring ethical working conditions, reducing plastic packaging and thinking twice before buying (and wasting) are some initiatives that could have a significant impact if adapted by enough people. Problem-solving is essential for these initiatives.

Circularity, seen as “a sustainable economic system where economic growth is decoupled from the resources use, through the reduction and recirculation of natural resources” (Corona et al., 2019: p.1), is being progressively adapted at a global level as it may benefit the industry, the environment, and citizens by reducing the carbon footprint. An individual’s carbon footprint is determined by the total amount of greenhouse gases that are generated by people’s actions whilst taking into account their living conditions. World’s electronic waste, for instance, responds to contemporary technological advances, the unsafely management of which has significant hazardous consequences (Wu et al., 2019; Yang et al., 2022b). Not only is e-waste potentially dangerous, but its components are also valuable and are prone to get stolen or illegally imported. However, the necessary infrastructure has not yet been developed or is insufficient to manage the e-waste that is locally generated (United Nations, 2022c). While hazardous waste can exhibit various characteristics such as being flammable, corrosive, reactive, or toxic, radioactive waste refers to any material contaminated by radionuclides at concentrations or radioactivity levels that exceed the quantities established by competent authorities and have no further use (OECD, 2010). Gross chemical contamination in

industrial areas and technological adversities might be different in nature, but both can cause environmental harm and grave damage to human health as well as genetic structures and reproductive outcomes.

3.4.13. Goal 13. Take Urgent Action to Combat Climate Change and its Impacts

Highly relevant to *The Paris Agreement*, a legally binding international treaty adopted by 196 parties and entered into force in 2016 (United Nations, 2015a), climate change is associated with causes as well as (adverse) effects in most areas of human and sustainable development (Coenen et al., 2022). Both the increase of the average temperature and the alarming sea-level rise (SLR), detrimental to human lives, animals and nature, are directly caused by global warming, greenhouse gas (GHG)⁷⁵ and human activity. Since the average temperature currently exceeds by 1.1 °C pre-industrial development levels, the aim is to keep it below 2 °C above said era by reducing emissions (Sorokin & Mondello, 2018). The SLR, however, has doubled in the last decade, which, along with higher mortality rates from disasters in highly vulnerable regions, urge collective action for GHG emission levels to drop by 43% in 2030 and to net zero⁷⁶ by 2050 (Razzaq et al., 2023).

While new buildings can apply multiple energy-efficient strategies in the construction process, existing buildings can benefit the most from retrofitting measures—improvements on the insulation performance such as retaining the heat for longer (Li et al., 2019)—to reduce energy consumption and integrating a renewable energy source. Additionally, there is a growing recognition of the need for comprehensive energy audits and assessments to identify areas for improvement and optimise energy usage in existing buildings, thereby further enhancing their sustainability and reducing their environmental impact (Maheshwari et al., 2017).

75. This occurs most of the heat is absorbed by the ocean.

76. Net zero refers to cutting GHG emissions to as close to zero as possible

3.4.14. Problem-Solving for Goal 14. Conserve and Sustainably Use the Oceans, Seas and Marine Resources for Sustainable Development

Adaptation in ocean and coastal ecosystems continues to be informed primarily by theory, as there is still limited evidence about implemented solutions (Seddon et al., 2020). The oceans and seas have now a level of acidification 30% higher than in pre-industrial times, and plastic pollution increased to 17 million metric tons in 2021 according to the *The Sustainable Development Goals Report 2023: Special Edition*. Similarly, plastic pollution levels are predicted to double or triple by 2040, which, along with the chain reaction that coastal eutrophication⁷⁷ sets off, leave the coast—and therefore human lives—at risk. In addition, unregulated and unreported fishing makes 20% of all fishing activity, which becomes an illicit practice that is both detrimental to the conservation of marine biodiversity and the sustainable management of fish stocks. The effort of legitimate fishers is therefore undermined, and the economic losses grow to a significant impact (United Nations, 2023).

The Agreement on Port State Measures (PSMA), established in 2009 and increasing in the number of signatures, helps to ensure fair competition, but is still far from covering overfishing according to the Food and Agriculture Organization of the United Nations (FAO)/Asia-Pacific Fishery Commission (APFIC) (2012). When it comes to coastal defence, hard-engineered structures such as seawalls are usually more expensive than nature-based adaptations, shifting from hard infrastructure to soft infrastructure for coastal defence. There is consensus on the potential of Other Effective area-based Conservation Measures (OECMs) (Cooley et al., 2022) to contribute to conservation and equity. For example, by recognising indigenous territories, to which the effects of ecotourism can adversely impact (Maxwell et al., 2020; Gurney et al., 2021). The capacity of these conservation tools to provide adaptation outcomes remains unexplored, so problem-solving is key for the recovery and protection of the largest ecosystem on Earth.

77. Coastal eutrophication refers to the excess nutrient loading such as algae in estuaries that eventually decompose and produce large amounts of carbon dioxide (Maître et al., 2021; US National Oceanic and Atmospheric Administration, 2023).

3.4.15. Goal 15. Protect, Restore and Promote Sustainable Use of Terrestrial Ecosystems, Sustainably Manage Forests, Combat Desertification, and Halt and Reverse Land Degradation and Halt Biodiversity Loss

Despite being the largest carbon and biodiversity reservoirs, forests are still facing significant losses as time goes by; global forest coverage alone has decreased by 0,7% in the last two decades, reaching almost 100 million hectares lost (United Nations, 2023). Deforestation occurs mainly due to agriculture expansion, which also contributes to global warming since it is a major source of CO₂ emissions (Assa, 2021) and increases the risk at suffering from some illnesses such as malaria (Berazneva & Byker, 2017). Furthermore, if these infrastructures are located in high mountain regions, their glacial hazard can vary from one valley to another depending on their tectonic and geomorphological situation (Stäubli et al., 2018). Similarly, the Earth is currently experiencing the largest extinction event since the dinosaurs disappeared according to the *The Sustainable Development Goals Report 2023: Special Edition* (2023). For example, the percentage of endangered reptile species increased to 1/5 in 2022 based on the International Union for Conservation of Nature (IUCN) Red List of threatened species. Not only is their habitat destroyed by human activity, but illegal wildlife trade puts their lives and evolution at serious risk.

Funding to mobilise and promote biodiversity conservation from all sectors, including the private sector, still represents the greatest obstacle to overcome when it comes to forest loss, land degradation and the extinction of species (Krauss, 2022). The protection and sustainable usage of biodiversity can be incentivised through state policies such as biodiversity-related taxes and offsets, some of which have only recently been implemented (Zu Ermgassen et al., 2022), for which problem-solving is crucial. Mainstreaming biodiversity across different sectors in order to mitigate climate change might encourage collective action in which regulatory and voluntary measures are combined. This can reduce fatal consequences such as the increasing risk of natural disasters and the loss of lives while ensuring the preservation of nature.

3.4.16. Problem-Solving for Goal 16. Promote Peaceful and Inclusive Societies for Sustainable Development, Provide Access to Justice for All and Build Effective, Accountable and Inclusive Institutions at All Levels

Albeit a multidimensional complex concept, peace has been identified as one of five main areas of pivotal importance for humanity, along with people, prosperity, the planet, and partnership (Hope, 2020). The latest number of civilian deaths due to ongoing conflicts affecting citizens worldwide shows how far countries are from achieving said goal. Similarly, the miscarriage of justice is evidenced by the alarming numbers in crimes such as organised crime, human trafficking or drug trafficking. The latter is a source of considerable inward and outward illicit financial flows, sometimes undetected due to an absence of universal access to justice. Unsentenced detainees, subject to the arbitrary actions of others, remained steady worldwide at 30.1% in 2015–2017 (Hope, 2020). Overcrowding in prison is still a major challenge even though prison capacity increased by 19% in the latest years, which suggests that the system would benefit from effective measures to ensure prisoners' safety and rehabilitation.

While the role of communication is enshrined in the *Universal Declaration of Human Rights* (1948) as the participation at family, community, national, and global levels, there is hardly any participation in decision-making for many groups within society. Full participation in society relies on equality between members of said society at all levels (Barrett & Marshall, 2023): with no representation at the parliament, where the average age is 51 years old at the time of this thesis, youth have very little to say to decide international matters. The proportion of members of parliament (MPs) aged 30 and under has remained at about 2% for the last five years (United Nations, 2023).⁷⁸ Law measures such as introducing quotas might help, but there needs to be a plan that is inclusive towards all citizens, where their concerns are represented regardless of their background.

78. That is, from 2018 to 2023.

3.4.17. Problem-Solving for Goal 17. Strengthen the Means of Implementation and Revitalize the Global Partnership for Sustainable Development

Collaborative arrangements between countries have gained importance by effectively addressing interrelated global sustainability problems, thus becoming an integral part of transnational regime complexes (Coenen et al., 2022). By partnerships, cooperation among stakeholders is precisely what the SDGs aim at: sharing a common framework of metrics can ultimately lead to the emergence of voluntary commitments as well as reciprocal learning (Long et al., 2022). Partnerships are particularly helpful where national policies are lacking or insufficient (Lui et al., 2020): by strengthening them, social and political measures can be improved and equitable development by including marginalised groups ensured. Social and economic difficulties as well as geographical limitations that could significantly hinder progress toward sustainability might be improved by the establishment of solid partnerships that encourage both engagement and dialogue (Almeida & Davey, 2018; Horan, 2019). The unprecedented rise in external debt levels, especially since the pandemic COVID-19, has had an impact on economic growth. As a consequence, high inflation reduces the possibilities for collective and individual prosperity, even though global trade reached a peak of \$32 trillion in 2022 according to the United Nations Conference on Trade and Development. Hence, problem-solving can be useful to attain critical global policy challenges.

There are multiple areas that could benefit from effective partnerships that are lacking, one of them being the equitable access to the Internet for all (United Nations, 2023). The network multiplies the access to information, which ultimately is connected to knowledge. No internet access is a huge lack of progress, but restricted access to academic resources presents various limitations to an individual too, such as having to pay to read articles or only having access to information through a higher institution. 2.7 billion people are still offline, highlighting that substantial work is still needed to achieve the universal connectivity target.

Funding for data and statistics is ever scarcer, and low participation from

local and non-state actors, such as universities, businesses, small NGOs, local communities and grassroots organisations, has been a consistent finding across studies (Horan, 2022). In Japan, citizen participation in energy and environmental policy processes increased after the 2011 Fukushima Daiichi Nuclear Power Plant accident, where the Tōhoku earthquake and tsunami resulted in the worst nuclear disaster in 50 years (Orita et al., 2020). The willingness to participate in citizen dialogue on energy and environmental policy as well as the acquisition of critical thinking toward these dialogues is yet to be researched, since the lack of awareness might be an obstacle when taking collaborative action (Nakamura & Chen, 2023).

All goals are dependent on each other to a greater or lesser extent: with no partnerships, ending poverty becomes an unreachable goal; without collective action to reverse climate change, life on land and below water will continue to suffer the aftermath of human activity; if universal access to justice does not exist, there is no hope for education for all and equality of opportunities between individuals. In this sense, problem-solving would also help to find patterns between the goals and connect solutions.

Though these goals might change in 2030 to a more nuanced version that responds to the needs and concerns of contemporary societies, they will always remain potential obstacles to overcome and therefore the continuous application of innovative plans and strategies becomes pivotal for their development. According to the *The Sustainable Development Goals Report 2023: Special Edition*, there is no mention of climate change in nearly half (47%) of the educational curriculum framework of 100 countries, despite the 94% affirmative reports upon being asked if it is included in their curricula (United Nations, 2023). Furthermore, the vast majority of teachers (95%) acknowledge how important it is to educate students on climate change severity, but just one-third could effectively explain the consequences of this phenomenon in their own region. Poverty, hunger and global warming are not inevitable, and neither is the fact that most people are not taught about useful everyday skills that could help them contribute to the world. Problem-solving can be an

engine to run one's personal life, including managing one's emotions or dealing with conflict, or even at the workplace to ease the relationship between co-workers. Because these skills are transferable, they can also be applied to a larger scale, way beyond the limited walls of learning: it can build the bridge towards a more conscious future that protects all living creatures.

4. Methodology

4.1. General Approach and Structure of the Thesis

Even though the thesis is of an interdisciplinary nature by combining British Literature and problem-solving, it follows the traditional structure for doctoral degrees in humanities in Spain and the UK. The thesis begins with the rationale of the study, where the objectives as well as the hypothesis are established and its relevance is justified; secondly, an exhaustive theoretical framework is included to provide the reader with context, followed by the methodology that has been employed; thirdly, four case studies illustrate ways to enhance problem-solving and a classroom experience was conducted as a real-life application of these skills; lastly, there is a discussion on what the results might reflect and a conclusion that entails potential future perspectives on the subject.

For the theoretical framework, sticking to two main bodies of research—the history of problem-solving in British Literature and problem-solving skills for a Global Citizenship, respectively—were specific enough to give enough information about how these skills have always been present and can become a game-changer for current global issues. In the first part, the evolution of enigmas from Medieval times to the contemporary era offers a comprehensive guide on how they have evolved, but the spirit of which remains intact; in the second, providing an introduction on reasoning and the changing landscape of problem-solving enables the reader to see this skill beyond abstract terms, and have an overview of its potential positive effects on the brain and real-life applications.

For this section, both physical (books, manuscripts) and digital (journals, media) resources have been employed. The libraries, the access to which was granted by the affiliation to a Spanish and a British university throughout the PhD, were the following: the Joan Reglà (humanities), Eduard Boschà (science) and Pelegrí Casanova (medical sciences) libraries at the Universitat de València (Spain), the main library and learning centre at the University of Surrey (UK), the British Library (UK), and the Magdalen Library and the Bodleian Library at the University of Oxford (UK).

4.2. Global Citizenship as an Application of Problem-Solving

Though problem-solving can have many applications, Global Citizenship is the ultimate goal of this thesis, since having a sense of responsibility towards the world's well-being can help to alleviate real-life issues such as climate change, or the lack of infrastructures in some areas in the world. Some experts in the SDGs have been contacted to confirm the importance of developing these set of skills and providing solutions to life-threatening situations, one of them being Dr. Arman Sarvarian, a reader in Public International Law at the University of Surrey, whose work with UN bodies led him to state that “[problem-solving] is definitely a skill that would be not only useful but I would say indispensable at the UN, given the typical complexity and difficulty of searching for solutions”.⁷⁹ The University of Surrey also had a Sustainability Institute that insisted on the importance of drawing projects towards a greener life and the inclusion of groups for which the cost of living and health inequalities had a disproportionate impact, the progress of the last years available in its latest *The Sustainable Development Goals Report 2023: Special Edition*.

4.3. Selection Criteria for the Case Studies

The case studies were set to represent some of the many approaches the solvers might take or discard when facing a problem. In the first case study, Sherlock Holmes as the basis of the usage of inference is a well-known literary example that could felt familiar to the reader and make the thesis interesting to a wider audience. The detective's thought process is particularly relevant to this thesis as he considers every single possibility before reaching a conclusion and does not give up until one of his hypotheses is confirmed. The expertise of Dr. Patricia Pulham, supervisor and head of department at the University of Surrey, significantly helped by narrowing down the selection of books and journals and suggesting the British Library as a supplementary resource.

79. This was stated through email correspondence, which cannot be included in this thesis due to data protection standards.

In the second case study, Lewis Carroll's engagement in different types of enigmas is analysed, both within his literary works and his mathematical contributions. Dr. Francine Abeles, Professor Emerita of Mathematics and Computer Science at Kean University, was contacted to confirm the development and adaptation of some of Carroll's ciphers for this thesis.

In the third case study, Ada Lovelace presented the ambition to go beyond thinking and practising to actually trying to go from an abstract idea to a real-life application. While diverse resources were consulted as usual, most information for this analysis stemmed from a copy of Taylor's *Scientific Memoirs* (1843) that was consulted upon appointment at the Old Library of the Magdalen College in Oxford as well as some of her correspondence provided by the Bodleian Library in the same city.

The fourth case study was intended to be the most practical of all, as problem-solving was needed in an emergency situation: the break of the WWII. The army's success depended greatly on the skills of the team at Bletchley Park, a codebreaking institution that analysed secret communication during the conflict. A deeper understanding of their usage of problem-solving was drawn from a visit to the centre in Milton Keynes and a meeting with Dr. David Kenyon, an expert research historian for the Bletchley Park Trust.

4.4. International Stay

During the research stay at the University of Surrey, there were monthly meetings with supervisor Professor Patricia Pulham in order to set goals, suggest corrections and ask doubts should there be any. A monthly report was also mandatory to submit before the end of each month where the student stated what had already been discussed during the meeting. This report was completed through the university virtual learning environment (SurreyLearn) and passed on to the supervisor, whose approval was needed. All meetings and reports were satisfactory.

Not only was the stay at Surrey an opportunity to review and improve the quality of the thesis hitherto, but it was also convenient to deep dive into

the case studies. The resources were then twice as many, and the visits to other libraries and meetings with professionals could not have been done without an affiliation to a British university.

Note G, the specific part of a document where Ada included her work about the initial steps for the first algorithm, was supposed to be available at the Bodleian Library in Oxford, but the copy had gone missing according to the team that was contacted at the time. After a few weeks, a librarian from the Magdalen College, also belonging to the University of Oxford, confirmed that a copy was available there under the reference Daubeny 90.A.11. Since this was part of the special collections, the access to manuscripts and archives during term time was limited to PhD students and researchers—and only Tuesdays and Thursdays from 9:30 am to 12:30 pm and from 2 to 4 pm by booking an appointment in advance. Thanks to the affiliation to the University of Surrey during the research stay, consulting Lovelace's notes was allowed on November 23rd, 2023 from 10:30 to 12:30 am. The consultation and citation in person of a copy of the original work, which is extremely hard to access online, was supervised by one member of staff of the Magdalen Library, who provided a desk and remained at the Old Library for further assistance. The visit was registered for future reference.

In order to get the reader's pass for the Bodleian library, a set of documents were brought to the admissions office, where the user also had to take a vow in their native language that involved the preservation of documents and manuscripts. Some of Ada's correspondence was consulted from 2 to 4 pm at the Weston Library upon request. When consulting archives and modern manuscripts for the first time, the user is asked to complete a conditions of access form relating to the Data Protection Act 2018 (UK), copyright legislation and personal digital photography. Dr. Patricia Pulham, the supervisor at the University of Surrey, facilitated a contact from the University of Oxford, Professor Stefano Evangelista, who kindly offered a room to stay overnight at the college if needed.

An email was sent to Bletchley Park in early October to ask whether it was possible to speak to someone about problem-solving and the role of women at the institution, since little information was available on the

Internet or at the libraries that had been consulted to date. A staff member redirected this email to Dr. David Kenyon, who agreed to meet and help with the research. A visit to the centre was paid on November 15th, 2023, at 10:30 am, followed by a 2-hour meeting with him at 11 am. His expertise, which goes back to getting his PhD and multiple publications about the WWI and WWII, was an unvaluable resource that significantly elevated the content of this thesis.

Nowadays, Bletchley Park is a museum that is opened all year round (except for 24th, 25th and 26th of December) and visitors are advised to leave time for a minimum of 4-5 hours to a complete day to spend at the facility, which includes optional tours, a cafeteria and a gift shop. At the time of this writing, the Park is open from 9:30 to 16:00 during the winter season (1 November–28 February) and from 9:30 to 17:00 during the summer season (1 March–31 October) (14:00 and 15:00 being the last admissions, respectively). Individual or group—including class—visits can be arranged through their official website or buy the tickets *in situ*, although the first is encouraged.

4.5. Classroom Teaching Criteria

While the thesis mostly relies on a qualitative, inductive approach to data, there are some quantitative results for the classroom experience: this session was thought to be an initial approach to how students could be encouraged to create their own ideas when given a set of situations, developing their problem-solving skills in the process. This was by no means intended to serve as the ultimate representation of the power of giving a set of enigmas to a group of people, but rather an attempt to deliver a class that went beyond the syllabus for the students to think outside of the box. Not only could they enjoy the class, but also build problem-solving skills in a dynamic environment and in a practical way.

The students at the *Philosophical texts in the English language* (Code 33252) class did not hold the level that they were expected to—equivalent to a B1 English certificate according to the Common European Framework of Reference for Languages: Learning, Teaching, Assessment

(CEFR)—due to various circumstances.⁸⁰ The initial plan of a theoretical and practical introduction to problem-solving distributed among two classes had to be re-adapted to their level, which significantly reduced the scope of the experience. Divided into two groups as there were over 50 students registered for the course, one lesson was given to group 1 on Monday and group 2 on Tuesday. This way, they could primarily work in teams and offer assistance to each other if anyone felt unsure about their English skills. The intention this time was to take an open and light-hearted approach to the problems that they had to solve and be tolerant with the responses. At the end, a survey was distributed so that some results could be gathered as a sample.

80. The syllabus is attached in Appendix 10.2.

5. Problem-Solving: Case Studies

5.1. If You Fail to Plan, You Plan to Fail: Sherlock Holmes' Method to Solve Crimes

Sir Arthur Conan Doyle (1859–1930) was born to a family who struggled to make ends meet, but managed to enrol him into Stonyhurst, an English boarding school run by Jesuits (Doyle, 1924). According to his own autobiography, *Memories and Adventures* (1924), he did not have fond memories of said institution, which he found dull even though he wrote poetry and read books in French for fun. His first story was written at the early age of 5, and he would charge his friends jam tarts as the price for the tales he made up, pausing at the most suspenseful moment (Pascal, 2000). At 16, he was eligible to go to the university since he passed his upper secondary education with honours, but he attended the Jesuit school Feldkirch in Vorarlberg, Austria, for a year upon his parents and teachers' advice (Doyle, 1924). He became the founder of the *Feldkirch Gazette*, but it got shut down due to his criticism towards Jesuit teachers' censorship.

Back in Edinburgh, he decided to become a doctor since he needed to support his family financially, although he had no interest in this field (Doyle, 1924). Staying at his home in order to save money, his family suggested recommending him as a doctor of Catholic authorities. He had no money to buy his own consulting room, but he still refused due to his agnostic beliefs. Hence, he began to write short stories to receive an extra income, one of them being “The Mystery of Sasassa Valley”, which got accepted in *Chambers's Edinburgh Journal* in 1879. Later, he was hired by his professor and surgeon Joseph Bell as an outpatient clerk, where he witnessed how Bell had “an uncanny and impressive ability to infer personal facts about the patients before they opened their mouths” (Pascal, 2000: p. 23). Doyle borrowed said theatrical display of talent—which arguably went beyond considering purely objective facts—for his well-known detective Sherlock Holmes.

Science did not hold the prestige that it does now, and some pseudosciences including phrenology—the reading of bumps on a skull to infer personality traits—and physiognomy—the study of facial

features to determine someone's character—were considered “capacious in scope” (Stiles, 2020: p. 371). At the end of the century, doctors and mental scientists were even “attempting to present hypnotism as a scientific practice, while mesmerism was associated with the supernatural and sinister powers of mind” (Grimes, 2011: p. 59). The fascination for speculative science, combined with the ambitions of some practitioners who strived for power or social recognition, were included in many novels of the time such as Mary Shelley's *Frankenstein; or, The Modern Prometheus* (1818), regardless of the consequences that the fictional patient or victim might endure.

Conan Doyle did not believe in a religion *per se*, but he did indeed explore the Victorian supernatural (Bates, 2021). His rationality could come up with a logical explanation every time that he experienced a séance, yet he was equally troubled and fascinated by their nature. While these two sides of him coexisted, he eventually set up a medical practice in Southsea (Doyle, 1924), which never passed the 300-pound mark a year. Through the lectures and debates of the literary society that he regularly participated in, he acquired the knowledge that he would later show through Sherlock Holmes. Holmes, a fictional consulting detective who investigates cases while pursuing criminals throughout Victorian and Edwardian London alongside his companion Dr Watson, would become the main character of a serialisation of stories that would forever mark the British literary panorama.

In 1891, Conan Doyle decided to give up medicine altogether to devote his time to his writing (Bates, 2021). In his series, he hoped to come up with a solid system by which enigmas and other mysteries “could be solved using only the clues given and the inspired application of logic—what he called ‘an exact science’ of detection” (Pascal, 2000: p. 59). Said invention was challenging because the first book that attempted to organise criminal evidence such as footprints or bloodstains in a similar way, *Dr. Hans Cross's Criminal Investigation*, was not published until 1891. Not only would this reasoning be fruitful crime-wise, but it also proved to be appealing for a reader without being too obvious or dull.

The Victorian reading habits of the time helped the serialisation and

distribution of Sherlock Holmes, since most journals and magazines were made of cheap paper and new printing techniques that adapted well to the daily routine of commuters and day travellers. The first appearance of Sherlock Holmes and Dr. Watson in the *Beeton's Christmas Annual* was in *A Study in Scarlet* (2001) [1917], which became popular enough for the text to be published as a book once the issue was sold out. *The Sign of Four* (1890) was the next Holmes novel to be released at the request of a North American publisher for the *Lippincott's Monthly Magazine*. It seems that Conan Doyle did not plan to continue the series, since Watson leaves Holmes at the end, but it became increasingly popular in the United States, partly because of the copyright laws at the time.⁸¹ Shortly after, he was contracted by *The Strand Magazine* for six Sherlock Holmes enigmas as short stories at £35 apiece (Doyle, 1924). The system that Doyle insisted on using was a well-known method at the time: the so-called deductive reasoning.⁸²

What Conan Doyle described as the Holmes' method when approaching cases is actually induction, as he takes into account context such as train times, distances, habits, preferences or tendencies. Deduction and induction were both often branded as simply "deduction" because society was greatly influenced by personalities such as John Stuart Mill,⁸³ who emphasised the role of induction as a method of (empirical) proof (Halliday, 2004). This is clear from his distinction between Deductive Method and Hypothetical Method in *A system of logic, ratiocinative and inductive* (1846). While the Deductive Method consists of three steps (induction, deduction, and verification), the Hypothetical Method lacks any proof of causes and laws by means of induction.

When applying induction to a case, a series of causes and laws are combined to calculate their effects—that is, concrete consequences are

81. The copyright laws enabled the United States to print any publication from the UK without paying any fees to the author.

82. Deduction and induction are used interchangeably in this chapter due to the historical connotations at the time.

83. John Stuart Mill (1806–1873) was a 19th-century English philosopher and economist, and one of the most influential figures of classical liberalism.

inferred from them. Once this step is completed, the consequences are verified to see if they match the case or not. The Hypothetical Method differs from this approach in the sense that the induction step is absent (Mill, 1846). In other words, causes or laws are merely assumed so that the solver infers specific consequences from them and proceeds to verify whether or not they make sense. According to Mill's theory, any logical or mathematical truth must be verified ultimately by referring to experience (Mill, 1846; Uchii, 1991). Trial and error is part of this process, and testing a hypothesis might require assuming that an explanation is correct before proving it wrong: hence, Holmes's take on *The Adventure of the Cardboard Box* (1893):

‘That is the problem which we have to solve,’ Holmes answered, ‘and for my part I shall set about it by presuming that my reasoning is correct, and that a double murder has been committed.’ (Doyle, 1974 [1917], p. 56).⁸⁴

As a practical comparison, we take a scenario where we see that someone seems to have breadcrumbs on their jacket. That person has expressed before that they have been to a bakery and that some of the loaves of bread that they purchased fell off the bag that they were keeping them in. Given this information, there is evidence that lead the recipient to believe that that person bought bread, which is what Mill would support. By Holmes' method, however, the fact that that person went to the bakery is assumed even if they did not say anything explicitly because that is the most likely cause for them to have some breadcrumbs or rest of flour on their clothing. Unlike Mill, Sherlock considers probability, and more specifically, an eliminative method which “is somehow combined with the consideration of probability or improbability” (Uchii, 1991). Consider the following extracts from (a) *The Sign of Four* and (b) *A Study in Scarlet*, respectively. While (a) is a more general statement on the need to practise problem-solving, in (b) he reflects on the fact of considering several explanations that initially do not match the case—similar to the

84. Please note that the stories were released separately first (hence the date next to it), but published as a compilation later (hence the date from the quote).

job of an algorithm—until one of them must be the right solution.

(a) 'My mind', he said, 'rebels at stagnation. Give me problems, give me work, give me the most abstruse cryptogram, or the most intricate analysis, and I am in my own proper atmosphere. But I abhor the dull routine of existence. I crave for mental exaltation' (Doyle, 1974 [1890], p. 14).

(b) 'By the method of exclusion, I had arrived at this result, for no other hypothesis would meet the facts' [Doyle, (2001) [1887], p. 140).

At its core, the deduction method in this context resembles induction better, as it stands for “the ability of unreflectively drawing conclusions from explicit or implicit premises, on the basis of their logical forms” (Reverberi et al, 2009: p. 1107) when said conclusion is not explicitly stated on the premises. Daily exchanges of information between people reflect its presence in everyday life. For instance, if a meeting among three friends is arranged but one of them states that they will not come should the weather be overcast, then the two remaining friends will infer that this person will not join the meeting if the sky is shrouded by clouds. Arguably universal, basic deductive steps are involved within word learning, formal logic or scientific hypothesis testing and potential confirmation (Mizrahi, 2020). This reasoning can be developed with time and lead to or help with more sophisticated reasoning. The latter, however, appears later in life, while also becoming increasingly complex and therefore unappealing for many.

Albeit seemingly simple, a deduction sequence involves several steps that must be taken in order to go from an initial premise to a conclusion, such as locating how these steps are articulated within the overall structure of said reasoning process and being able to temporarily store the representations that are needed for that specific sequence (Newell & Simon, 1972). The ability to infer information plays a massive role to succeed in problem-solving scenarios, deductive inference being a “multi-faced phenomenon, not necessarily involving only a single psychological

mechanism” (Reverberi et al, 2009: p. 1107). In other words, it involves a series of steps that might vary from one person to another or from situation to situation.

Not only is this process a daily routine for individuals, but the ability of grasping and selecting information can also be employed throughout multiple fields such as overcoming problems derived from coding or coming up with a clinical diagnosis. which are often presented as a mystery to medical professionals (Sopeña, 2010; Hong, 2022). Presupposed by mental models as well as mental logic—the two main components of human deduction—along with more advanced reasoning abilities, deductive relations among grammatical structures or even loose thoughts are a fundamental cognitive activity.

According to the Mental Models Theory,⁸⁵ reasoning involves the creation of analogical structures that mirror real states (Johnson-Laird, 1983). Unlike in mental logic, said structures do neither demand rule-like logical operations nor “the explicit representation of variables or quantifiers: the ability to represent examples of real states of affairs grounds reasoning” (Reverberi et al, 2009: p. 1108). In the mental logic framework, this type of reasoning comprises short mental proofs which consist of a set of rules and procedures, Direct Reasoning Routine (DRR) being one of them. This part of the mental-propositional logic enables the human brain to move from prompts to conclusions in a finite—and therefore more efficient—number of stages (Braine & O’Brien, 1998). Though phrased differently because these models had not been coined at the time, Holmes alludes to reasoning multiple times throughout his interactions with other characters in the Sherlockian world.

Holmes finds reasoning a core component of his resolution of crimes since it is a primitive and universal elementary experience, even though not everyone develops the tools for the acquisition of more sophisticated or secondary reasoning strategies as he does. While primary reasoning is spontaneous and intuitive to a certain extent, secondary reasoning represents a more sophisticated and non-automatic task that requires a

85. A mental model is an internal representation of external reality.

great deal of motivation as well as time and effort (cognitive resources) (Lespiau & Tricot, 2022). Furthermore, it becomes increasingly difficult and time-consuming for the brain to acquire since there is not enough time for adaptation (Lespiau & Tricot, 2022). Additionally, as mentioned earlier in this chapter, it might become unappealing and frustrating for many, as it requires investing time and practice to polish these skills.

The inferential strategy that Holmes employs is the result of his observation and a brilliant ability to test theories, deciding which ones to discard later should they not be consistent with the data, no matter how attractive or likely they might seem at first (McAleer, 1994). In other words, Holmes' methodology relies on gathering information to accommodate the facts and processing observations in hopes that he might eventually find a theory (model) that explains said data. See, for instance how he points out in (c) that a dog does not bark because they know the culprit well in *Adventure of Silver Blaze*, which would not have occurred had they been complete stranger (Doyle, (2000) [1894]):

(c) 'Is there attention any point to which you would wish to draw my attention?'

'To the curious incident of the dog in the night-time.'

'The dog did nothing in the night-time.'

'That was the curious incident,' remarked Sherlock Holmes (p.34).

Holmes points out what did not happen as opposed to what was expected to happen. This process might include elaborating temporary hypotheses before eventually reaching a solution: while all facts are correct, the interpretation might be forced to change as potential explanations are tested. In *The Hound of the Baskervilles*, Holmes assesses how reasoning starts, reassuring his companion that it goes beyond making a simple guess. In other words, he is suggesting trial and error in (d), and the conventional steps one should take when applying problem-solving skills to any given situation, such as going back to the initial statement should a hypothesis fail to be confirmed.

(d) ‘We are coming now rather into the region of guesswork,’ said Dr. Mortimer.

‘Say, rather, into the region where we balance probabilities and choose the most likely. It is the scientific use of the imagination, but we have always some material basis on which to start our speculation’ (Doyle, 1974 [1902]: p. 47).

In (e) he alludes to probability again and refers to a solution that did not seem the most likely at first but that becomes the ultimate solution after the other hypotheses have been verified to not work.

(e) ‘You will not apply my precept,’ he said, shaking his head. ‘How often have I said to you that when you have eliminated the impossible, whatever remains, *however improbable*, must be the truth?’ [Doyle, *The Sign of Four*, 1974 [1890], p. 54).

Considering more unusual explanations is on brand with the historical context these stories grew up in, where an ambivalence between the science and supernatural coexisted. Conan Doyle himself had been interested in spiritualism since 1886 (Grimes, 2011). In *A Study in Scarlet*, Holmes infers that Dr. Watson has been in Afghanistan because of peripheral knowledge: firstly, Watson is an army doctor, and his skin looks tanned, which is unlikely in British weather. Therefore, he must have been in the tropics. Holmes is also aware of Watson’s last deployment, which makes the mystery a matter of narrowing it down to the potential geographical regions that have that climate and where the British Empire maintained an active military presence. Afghanistan met all the criteria during the second Anglo-Afghan war (1878–1880), hence this country being Holmes’s most satisfying candidate.

Regardless of what the domain of expertise under scrutiny is, empirical evidence such as this correct assumption from Holmes relies on the fact that both specific and more abstract knowledge coexist in human memory (Didierjean & Gobet, 2008). The knowledge that Holmes makes use of in a case was originally constituted by a series of specific instances, which

were later adapted to the situation that he faced by deleting numerous elements and replacing them by variables. In other words, slightly different versions—and therefore representations—of a problem that he had already encountered before. Schematic knowledge in expert memory also contains semantic information on the most likely continuations of a specific situation that the subject experiences. Thus, if the outcome of said event differs from what was initially predicted by the activated knowledge structure, this provokes a chain reaction that leads to an expectation failure (Schank, 1982; Kolodner, 1993).

Holmes becomes the key for the interception of crimes and culprits, “receiving and transmitting messages of criminality across London” (Grimes, 2011: p. 37). It would have been expected from him to have a reluctant attitude towards the supernatural, which he sometimes insists on as per his statements in *The Adventure of the Sussex Vampire* (1924), where he refuses taking a case dealing with supernatural creatures: “The world is too big for us. No ghosts need apply” (1974 [1927], p. 105). Nevertheless, he admits to Watson that sticking to the so-called purely rational might make them overlook pivotal clues, such as in *The Adventure of the Copper Beeches* (1892), where he states that “Crime is common. Logic is rare. Therefore, it is upon logic rather than upon a crime that you should dwell” (1974) [1892], p. 290), but that by “avoiding the sensational, I fear that you might have bordered on the trivial”. Rather than worsen the quality of his deduction, his sensitivity to spiritual insight and acceptance and acknowledgement of hypnotic trance stances help to polish his abilities.⁸⁶ Taking all types of sources in order to solve a crime, even the unempirical, allows him to consider more possibilities than if he were to stick to pure scientific explanations.

His openness towards all types of peripheral context provides Holmes with a big reputation of cracking the unsolvable by continuously gathering

86. While Victorian innovators focused on producing new diagrammatic and notational techniques, Victorian logicians considered classical logic to be faulty “not only for its incompleteness but also for its blindness to its own arbitrary and conventional nature, its presumption of absolute authority” (Henderson, 2014: p. 86). In other words, there were limitations to classical logic that did not meet the requirements and continuous experiments of the time.

and reorganising “textual minutiae, details, trifles, and fragments” (Turner, 2018: p. 439). The very process of archiving information from everywhere, no matter how trivial it might seem, is as crucial as the outcome, for one never knows when interpreting said piece of information might be needed at a later time. Being an observing machine allows Holmes to retrieve details in an unforeseen context: rather than sticking to the conscious observation of important events, the detective collects data from everyday life, including that in the newspapers, such as the “processing and indexing of information gleaned from the agony columns” (Turner, 2018: p. 442). In Victorian times, the agony column was the ultimate crossover between public and private information, a section within a newspaper that turned people’s lives upside down.

Everyone, including the Queen Victoria herself, reportedly read the agony column as a hobby (Turner, 2020). Secret advertisements enabled readers to manage the isolation of the city life or even surrogate forms of intimacy for communities in which personal relationships were increasingly formed by strangers, expressing “isolation and mobility of modern life at the same time” (Rubury, 2009: p. 55). Even the most seemingly innocent of exchanges awakened curiosity and intrigue since it could be decoded into something worth hiding. Say, for instance, that the agony column contains the following message, which goes unnoticed for the average reader:

«To James. Meet me this afternoon at the pastry shop at Macclesfield road in Holmes Chapel. Augustine is well again. Betty.»

If this is published in a daily local newspaper, the reader is left with multiple questions: why would someone go through the trouble of arranging a meeting through the newspaper instead of saying it face to face or via a private letter? Is the time important? What could be so urgent that the recipient is informed the same day of the meeting? What is the relationship between the three people that are mentioned, is it forbidden by their parents or because of social class? Is Betty James’ secret lover, or is she Augustine’s confidante and acts as a messenger between the

two? Will this love affair maim them too?

Though it remains unexplored as a media artefact, the agony column served as a microgenre in Sherlockian adventures. This section enabled a “marketplace for everything from soaps to coffins, as well as for miscellaneous mysteries of human drama” (Turner, 2018: p. 427). The melodramatic nature of the column carried potential risks too for those who actively used it to communicate: in 1870, one party’s interest in the newspaper was gathered as evidence of an extramarital affair by a witness to an Edinburgh case (Rubury, 2009). The level of complexity of the messages varied greatly: some only relied on code names or endearing nicknames; some others employed an agreed popular cipher between the two parties; the bravest ones, however, invented their own ciphers, alphabetic and/or numeric. Hence, Holmes was constantly scanning the newspaper, searching for stimulating cases that might be worth spending time on. In *The Adventure of the Red Circle* (1911), the *modus operandi* of the culprit seems evident to Holmes, who says: “How is any news or any message to reach him without? Obviously by advertisement through a newspaper” (Doyle, (1974) [1917], p.78), upon being asked about his next move.

Criminals were among the most frequent users of this clandestine way of communication because the newspaper’s front page was one of the places that the police would be the least likely to look for clues. The stories were subject to the exploitation of the medium by lawbreakers to share and obtain secret information within their network. Even small advertisements were prone to be perceived as suspicious, because counterfeit employment agencies or questionable patent medicines could hide a money-making scheme. The audience’s perception that even description of products on the newspaper could be polluted with new ways of criminality was not dissimilar to fiction, especially detective fiction—hence, its huge role in the Sherlockian world. Within this hectic and somehow surreal epoque, one issue could print an advertisement in hopes of locating a missing person while that same person that some were desperately looking for might be using the same section to reenter society under a new undercover identity (Rubury, 2009). Ordinary people

could be leading double lives, and no one would be able to know.

In *The Adventure of the Dancing Men* (1905), Sherlock Holmes himself notes the role of encoded communication by encountering a cipher that shows a secret language that the sender taught the recipient, who cannot speak it with anyone else (1974 [1905]):

I am fairly familiar with all forms of secret writings, and am myself the author of a trifling monograph upon the subject, in which I analyse one hundred and sixty separate ciphers; but I confess that this is entirely new to me. The object of those who invented the system has apparently been to conceal that these characters convey a message, and to give the idea that they are the mere random sketches of children (p. 89).

Through the role that it played within the stories, Conan Doyle embodied the multiple ways in which this format added to the content of the personal advertisements and how such a condition was key in the way that the audience responded in his Sherlockian adventures, since they both represented puzzles to solve. The readers' reactions could either significantly enhance or diminish the column's impact, so in order to get a message across, the reshaping of the form and the potential interpretation of the meaning by the audience needed to be meticulously thought through. If the sender did not want to catch anyone's attention, a more mundane or casual style would do the job, whereas a message that served as a red herring should leave enough room for interpretation and chaos. Holmes illustrates how, through acute judgement, peripheral context, observation and the strengthening of reading habits since an early age—that is, through the acquisition of problem-solving skills—the messages in the agony columns that the average passive reader might as well have missed could be carefully decoded.

Conan Doyle's writing contributed to elevate this section of the newspaper beyond a sensationalist space to become an interactive platform between author and reader. This reciprocal exchange of the 19th-century agony columns provided the reader with a more accessible yet

unstable relationship from media producer to mass consumption, a wide reach to a mass audience full of curiosity that was willing to purchase condensed messages. The development of problem-solving was enhanced by enigmas, mysteries and various types of codes, which Holmes as well as the enthusiastic consumer—which could be an average commuter on their way to work—would have to solve to avoid being completely kept in the dark. Although it was not perceived as a unique encounter since newspapers were published several times a day, this literary experience provided a new kind of puzzle to unravel and promised entertaining brain work for a loyal community of fans. This caused interest in this medium to arise, and the opportunity for readers to practise and develop their problem-solving, critical thinking and associative abilities.

5.2. Strategy Sets the Scene: Lewis Carroll’s Engagement in Encoding Information

Coming from a long line of clergy, Charles Lutwidge Dodgson (1832–1898) received strict Christian upbringing. Charles inherited these deep religious values from his father Reverend Charles Dodgson, along with his interest in the world of mathematics and a thorough training in this subject, English Literature, Latin and Christian theology (Winchester, 2011; Wilson & Moktefi, 2019). From a very young age, Dodgson inquired his father to explain books to him that he would find around the house, often including advanced arithmetic such as logarithms that he insisted on learning in spite of his father’s advice of waiting until he was older. Upon their move from Daresbury to Croft-on-Tees, the family’s income increased, and Charles was sent to a private school at Richmond (Green, 2023), where he would expand his knowledge and prepare him to potentially pursue a career in the Church.

Dodgson was already composing Latin verse and a page of geometry by the age of 12, and at around 23 he constructed the allegedly earliest example of a three-dimensional maze for the family magazine *Mischmasch* (Wilson & Moktefi, 2019). Well-placed at Oxford University, he was elected as a classman to work towards a four-year Honours

degree in Classics and Mathematics as opposed to the three-year passmen undergraduates. Pupils were required to undertake responsions—that is, various papers on Latin and Greek authors, translation from English into Latin, grammar, and mathematics—moderations, and finals. Despite long days working on the examination, Dodgson emerged with a third-class in classics, but came top of the entire list in mathematics (Wilson, 2008).

These results enabled him to teach privately at the university, where he sometimes drifted away from traditional lessons to incorporate more dynamic elements such as puzzles and stories, in hopes that more serious mathematical conventions would be conveyed (Wilson & Moktefi, 2019). In the meantime, he occasionally published his writings until the release of *Alice's Adventures in Wonderland* in 1865, inspired by the stories that the author would make up to entertain the Liddell sisters on boating trips (Susina, 2001). The original manuscript *Alice's Adventures Under Ground* was presented to Alice—one of the sisters and main muse for the well-known title—around Christmas in 1864, since she had been one of the first people who had encouraged him to write the stories down in the first place (Green, 2023).

His dual passion for literature and mathematics is reflected on his very pen name, Lewis Carroll. Dodgson created his pseudonym as an anagram from a combination of simple cipher techniques and the English and Latin alphabets. He latinised his middle name Lutwidge to Ludovicus in Latin and then anglicised said form to Lewis; he applied the same process to Carroll, which he obtained by converting Charles into Carolus first and then unlatinising it again (Burgess, 1982). Carroll⁸⁷ used to carry with him a variety of mechanical puzzles (Gardner, 1996): he presented an obvious interest in problem-solving as shown by the variety of mathematical and literary recreations that he developed throughout his life (Moktefi, 2018).

Carroll trained his mathematical skills by solving problems of various natures, as he told throughout his diaries, and would later also mention in *Pillow Problems* (1895). The entries related to logic and mathematics

87. For clarity's sake, Carroll is the name that will be used from now on to address the author.

were left out in the two volumes of *The Diaries of Lewis Carroll* for Oxford University Press (1954). They were thought to be of little interest to the reader yet were recovered in another edition of the *Diaries* which was published under the editorship of Edward Wakeling in 1855-1857, and revealed many exercises that he came up with during his sleepless nights. Likewise, a play on words was an activity he happily indulged (Gardner, 1996), as seen on the following riddle:

Invented what I think is a new kind of riddle: ‘A Russian had three sons. The first, named Rab, became a lawyer; the second, Ymra, became a soldier. The third became a sailor: what was his name?’

The tricky element of this problem is the names, which are connected to each profession when spelled backwards: Rab is bar, which in law stands for a professional association of lawyers; Ymra reverses to army, the group profession to which a soldier belongs; thus, if the third one became a sailor his name should be Yvan, because it is an actual name that becomes navy when reversed (Gardner, 1996). His work on ciphers might not be as well-known as his literary contributions, but he came up with up to five ciphers that disclosed an exhaustive and often intricate mathematical system⁸⁸ that could be later applied to linguistics.

Carroll created the first of his code systems, a subset of a simplified form of the Vigenère cipher, though he did not know about his reinvention at the time (Gardner, 1996). Named the “key-vowel cipher”—an improved version of which was also issued anonymously that same year, printed on both sides of an undated white card—, it required just five out of the 26 available alphabets, making keywords more simple but also less secure.

88. Much of his academic work is related to determinants—a particular number or expression related to a matrix, from which important algebraic and geometrical characteristics can be deduced and matrices. The larger the matrix is, the more complicated it gets to find its determinants, a 5x5 matrix being a laborious task—Carroll, however, managed to create an innovative method that only ever required the calculation of 2x2 matrices (Rice & Torrence, 2007; Rice, 2011).

Table 4

Template of the key-vowel cipher

	A	B	C	D	E	F	G	H	I	J	K	L	M
A	Y	Z	A	B	C	D	E	F	G	H	I	J	K
E	Z	A	B	C	D	E	F	G	H	I	J	K	L
I	A	B	C	D	E	F	G	H	I	J	K	L	M
O	B	C	D	E	F	G	H	I	J	K	L	M	N
U	C	D	E	F	G	H	I	J	K	L	M	N	O

	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
A	L	M	N	O	P	Q	R	S	T	U	V	W	X
E	M	N	O	P	Q	R	S	T	U	V	W	X	Y
I	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
O	O	P	Q	R	S	T	U	V	W	X	Y	Z	A
U	P	Q	R	S	T	U	V	W	X	Y	Z	A	B

Note. This table is taken directly from Abeles’ article *Lewis Carroll’s ciphers: The literary connections* (2005: p. 699). The table is divided into two for clarity purposes.

Although seemingly messy at first, encoding with this system is fairly easy: the vowels that the sender and the recipient have previously agreed upon must be taken from a keyword and correlate those with the plaintext that is intended according to the top row in Table 4, so that a ciphertext is obtained. The key thing to remember is that only vowels are relevant: a practical example of this cipher is included on the following page.

The keyword that the two people involved have set is “Woodvale”, a suburb of Perth, Western Australia. The sender (a powerful woman who sells potions and natural remedies undercover) wants her secret message to be encoded since her and her client cannot be seen together in public, so she needs to turn the phrase “meet me at midnight” into a cipher. Looking at Table 4, since the first vowel of “woodvale” is “o” (column on the very left), and “m” is the first real letter from the message (top first row), the letter “n” is obtained, and therefore this will be the first letter of the cipher. The same process is executed until the cipher is finished,

no matter how many vowels the keyword has: “woodvale” only has four to work with, while the message has 16 letters. Thus, the keyword is repeated four times until the number of vowels matches the number of letters of the original message, as Table 5 shows.

Table 5

A practical example using the key-vowel cipher

K	W	O	O	D	V	A	L	E	W	O	O	D	V	A	L	E
T		M	E			E		T		M	E			A		T
C		N	F			C		S		N	F			Y		S

K	W	O	O	D	V	A	L	E	W	O	O	D	V	A	L	E
T		M	I			D		N		I	G			H		T
C		N	J			B		M		J	H			F		S

Note. K stands for “Keyword”, T for “Text” and C for “Cipher”. The table is divided into two for clarity purposes.

Through this system, “Meet me at midnight” would become “NFCSNFYSNJB MJHFS”. To make it even more obscure, Carroll added three random letters at the beginning of the cipher and two at the end. Moreover, he padded the text with a random letter (null) in-between each real letter of the cipher, which had no real value and would confuse the reader. An example of this random letter placement and ultimate version of the intended text would be the impressively long cipher “REDNFFVCGSTNHFQYFSXNPJEBMMAJKHAFVSSN”.

Needless to say, this was the first and therefore also the easiest system that Carroll invented, which he polished and expanded to the entire alphabet in 1868 with a $\text{key} + \text{plain} = \text{cipher}$ formula. Another fairly easy one was the Telegraph cipher, with no nulls employed to obscure the code because he just used it to communicate with childhood friends (Abeles, 2005). Similarly, here the two parties are provided with a keyword (indicated as “K” on the table) and a message-alphabet (indicated as “M”). The main characteristic of this one is that there is an extra “a” at the end of the

second alphabet that will determine which letter the original message turns into, as shown in Table 6.

Table 6

Template of the Telegraph cipher

K	A	B	C	D	E	F	G	H	I	J	K	L	M	N
M	A	B	C	D	E	F	G	H	I	J	K	L	M	N

K	O	P	Q	R	S	T	U	V	W	X	Y	Z	
M	O	P	Q	R	S	T	U	V	W	X	Y	Z	A

Note: The table is divided into two for clarity purposes. K stands for “Keyword” and M for “Message-alphabet”.

Taking “woodvale” once again as the keyword and “midnights” as the intended text, the cipher is obtained by sliding the message-alphabet so that the letter of the plaintext is placed right under the keyletter: the letter right above the additional “a” (red in Table 6), originally at the very right end of the message-alphabet, is the letter that will be used in the cipher.

Table 7

Example of the usage of the Telegraph cipher and the results for the intended text “Midnights”.

K	A	B	C	D	E	F	G	H	I	J	K	L	M	N
M	R	S	T	U	V	W	X	Y	Z	A	A	B	C	D

K	O	P	Q	R	S	T	U	V	W	X	Y	Z	
M	E	F	G	H	I	J	K	L	M	N	O	P	Q

Note: The table is divided into two for clarity purposes. K stands for “Keyword” and M for “Message-alphabet”.

As an example of the conversion of the first letter, Table 7 shows the first letter in “midnights”, “m”, placed right under the first letter of the

keyword (woodvale), “w” (both in bold). Now it is time to pay attention to where the original “a” (red) ends up: it seems that it falls right under “J” in the keyword (grey background), and therefore this will be the one that has to be employed in the cipher. The same process is applied to every letter, the result of this short message being “JGLQNUELE”.

The main goal for the last system that he created was to remember dates, or even logarithms, hence its name The *Memoria Technica* cipher (Table 8). To avoid forgetting the logarithm of 106 = 0.0253059, with the leading 0 understood, he created a longer poem where the underlined letters in the third line would become 253059.

Table 8

Template of the Memoria Technica cipher

1	2	3	4	5	6	7	8	9	0
b	d	t	f	l	s	p	h	n	z
c	w	j	qu	v	x	m	k	g	r

Six months I have travelled unshaven,
That’s exactly one half of a year:
I have changed from a doye to a raven —
But I will not be shaved, even here!

Note. Table 8 is taken directly from Abeles’ article *Lewis Carroll’s ciphers: The literary connections* (2005: p. 704).

Using an uncomplicated consonant scheme, he would compose rhymed couplets in which the intended date to remember is encoded by the last consonants underlined at the end of the last line. The second system he developed from a chronological perspective, however, was the most difficult one and worked based on a plain-key = cipher ($C = P - K$). Influenced by his classical studies, it consisted of a Latin alphabet

arranged as a 5x5 matrix. Numbering the rows and columns 0 to 4 from right to left and from top to bottom (as shown in Table 9), each letter corresponds to two coordinates, e.g. L = (2,0). Starting at the beginning of the keyword “woodvale” again and taking “London” as the message, “W” (4,0) is subtracted from the first real letter “L” (2,0), which would map (3,0), and so on. Although one might think that 2–4 equals –2, there are no negative numbers, so the way to find the row “L” is to go right from W (key) to the beginning of the row again, through A, F, and finally L, which leaves the number 3 as the first coordinate and 3,0 as the first real letter of the cipher.

Table 9

Template of the Matrix cipher.

A	F	L	Q	W
B	G	M	R	X
C	H	N	S	Y
D	I	O	T	Z
E	K	P	V	*

Because the greatest vulnerability of any cipher is the periodicity of the keyword, he added two pairs of parenthesised numbers at the beginning, the first being a random number and the second number denoting the current position of the keyletter in the encipherment process (e.g. 2.6 for “a” in “woodvale”, because it is the sixth letter); the second pair also consists of another random number and a change in the letter (e.g. 1.5, which stands for a message from the sender to let the recipient know that even though “a” is the current position and the next one should be “l” in woodvale, please start by “v” instead). The final message for “London” starting with “v”, including nulls at the beginning and end as well as in-between each letter, would be (2.6)(1.5) 24.41.30.23.19.02.82.04.60.33.7 1.22.22. By addressing this issue, Carroll unlocked an unbreakable nature for his cipher.

Carroll’s take on modern logic was not limited to ciphers, *A Tangled Tale*

(1885) and *The Game of Logic* (1886) and *Pillow Problems* (1893) being some of his contributions to the representation of categorical propositions and the creation of his own diagrams, which seemed to have “had little impact on his immediate followers” (Moktefi, 2021: p. 366). Despite this initial bump on the road, his diagrams were actually praised later in time for its efficiency on working with complex problems, as opposed to the struggle that the Venn diagram endured when the number of terms kept on increasing.

In the preface to the second edition of *Pillow Problems*, Carroll noted how “sleepless nights” had been replaced by “wakeful hours”, since “mathematical calculation would be more likely to delay, than to hasten, the advent of sleep” instead of a remedy for *wakefulness* (Carroll, 2015 [1885-1895], p. 10).⁸⁹ He suggested that an hour of calculation would prevent him from worrying about some other topic, and that therefore these problems made sense as a way to keep the worry at bay.⁹⁰ Far from being intended to appeal to an intellectual audience, they were rather intended for those who Carroll called “ordinary mathematicians”—that is, the average reader who could be encouraged to see actual results from practising and attempting to solve them (Carroll, 2015 [1885-1895], p. 14). In other words, he provided ways to develop their problem-solving skills.

While Carroll found some of the mathematical advances of his time nonsensical, including imaginary numbers, he did subscribe to is the nonsense literary movement. This trend consisted of a combination of folklore and intellectual parody, where Carroll produced a narrative that can come across as unbalanced and even humourless (Green, 2023). Though difficult to define in absolute terms, this subgenre could be presented in multiple forms such as gibberish language, political satire, or

89. Carroll’s italics.

90. The original text goes as follows: “I must choose between two courses, viz. either to submit to the fruitful self-torture of going through some worrying topic, over and over again, or else to dictate myself some topic sufficiently absorbing to keep the worry at bay. A mathematical problem is, for me, such a topic; and is a benefit, even if it lengthens the wakeful period a little. I believe that an hour if calculation is much better for me than half-an-hour of worry” (Carroll, 2015 [1885–1895], p. 10).

linguistic absurdities. The origin of this movement goes back to a volume of limericks by Edward Lear,⁹¹ where he changed traditional humorous five-line poems with the ABBA rhyme scheme into a variety of formats, and helped to popularise these devices in 1846. *The Book of Nonsense* (ca. 1861), devoid of obvious meaning, encouraged the audience to play with words and sounds (Brown, 2013). Through the manipulation of language, however, it might have defied common sense, but did not necessarily become meaningless: “non-sense”, like any other antonym, exists in relation to “sense”. By constructing and deconstructing the meaning of a word or expression, the reader understands the arbitrary nature of semantics.

There is not much consensus on the meaning of many scenes, a common outcome of this genre, chapter 5 “Advice from a Caterpillar” being one of them. On the one hand, literary scholar Melanie Bayley (2009) suggested that the word “temper” in the caterpillar’s recommendation to Alice, “keep your temper” (2015 [1865]: p. 55),⁹² retained the Victorian meaning of the proportion in which qualities are mingled. Thus, the character could be advising the protagonist to keep her body in proportion—a hint at the author’s views on the potential dangers of the new symbolic algebra—no matter what the size, since it continuously changed in Wonderland—a reflection of Carroll’s love of Euclidean geometry. On the other hand, Farebrother’s alternative explanation involved a cultural reference to the words engraved on brass gaming tokens during the Victorian and Edwardian periods to remind children of “their charges of proper decorum when playing indoor games” (2015: p. 99).

The combination of mathematical form and linguistic content is moreover deliberate in Lewis Carroll’s construction of nonsense, the intention of which was satirising the new cosmologies that sciences were generating at this time (Brown, 2013). These avant-garde theories in Victorian

91. Edward Lear (1818–1888) was an English artist and poet, better known for his popular literary nonsense poetry collections, especially his limericks, a form he popularised, as well as botanical drawings and some prose contributions.

92. From this point onwards, all the quoted pages of *Alice in Wonderland* refer to the edition that is specified in the bibliography.

mathematics such as that of invariants or non-commutative algebra were therefore suitable to nonsense literature, where Carroll used to correlate controversial academic situations through transposing them into literary analogies (Forbes-Macphail, 2013). His characters became happy, free, confused and lonely at the same time, Alice representing all these emotions in one.

Upon her fall down the rabbit-hole, Alice enters this state of confusion—sometimes comparable to delusion—where she tries to escape her adult relatives who compel her to endure books without pictures or conversations. Her descent into the unknown territories of insanity, however, forces her to outgrow Wonderland, as well as “master its irrationality and assume the authority of a sensible adult” (Boe Birns, 1984: p. 460). Characters are adult yet childlike, a possible combination of satire of the rigid Victorian parent and a childish behaviour such as throwing tantrums. Alice, who had been perceived as crazy by her family because of her wild ideas and vivid dreams, becomes the only sane in Wonderland.

The cat corroborates said accusation when he tells Alice that she can’t help to go among mad people even though she does not want to, since “we’re all mad here. I’m mad. You’re mad.” (p. 81). The expression “mad as a hatter” describes someone who is bound to have an erratic or unpredictable behaviour, but it did not originate from the series: its etymology was possibly connected to the hat-making industry and the toxic substance that industrial workers would use during the 18th and 19th century, mercury nitrate (Rees, 1987), which caused illnesses affecting the nervous system. Faithful to the saying, the Hatter—popularly referred as the Mad Hatter—is responsible for a great number of crazy and often unsolvable riddles, the most famous being “Why is a raven like a writing-desk?” in chapter 7, “A Mad Tea-Party” (p. 87).

What seems like a source of entertainment for Alice, who initially says that she is glad that they have begun to ask riddles, turns into a frustrating argument between the two. Albeit confident at first, some confrontation occurs when she nonchalantly suggests that “saying what someone means” and “meaning what someone says” is the same thing, which both

the Hatter and the March Hare have their reservations about. They insist on the distinction providing another example which would not work if given these linguistic rules: “Why, you might just as well say that ‘I see what I eat’ is the same thing as ‘I eat what I see!’” (p. 87) and therefore discarding a commutative property between both expressions.

After a presumably long deliberation, Alice gives up, willing to admit defeat and expecting the right answer to be provided by the Hatter, who replies that he does not know either, creating a nonsensical riddle and altering the traditional dynamic of a puzzle. Anonymous and mostly amateur readers began creating their own theories that would potentially palliate their dissatisfaction (Susina, 2001), which are still available scattered throughout the Internet today. Some might say that a raven eats worms, while a writing desk is worm-eaten; others attempted to connect both things with the rude remarks they make, the raven through his caws and cackles and the writing desk through the author that writes on it. The only right problems remained unsolvable until Carroll’s update in 1896.

In the preface to a Christmas edition of *Alice in Wonderland*, Carroll addressed this issue and provided what he thought to be an appropriate answer, in which he proposed that a raven was like a writing desk “because it can produce a few notes, tho they are very flat; and it is never put with the wrong end in front!” (1896: p. 71). This statement meant that both ravens and desks could produce notes, and that they were flat because a) ravens lack significant variation in pitch and b) a handwritten note lies flat on the desk. The word “never” in his explanation was intentionally spelled “nevar” in an early draft of the preface, a witty hint at “raven” spelled backwards, but his literary easter egg was mistakenly corrected by a proofreader.

Carroll admitted, however, to this solution being an afterthought since the riddle was invented with no original answer at all. Contemporary scholars still work on clever solutions to the problem which must fit the overall intellectual patterns that the author has established throughout his literary production, because otherwise, “clever as the solution may be, it will not give us that sense of aesthetic rightness” (Boe Birns, 1984: p. 461), such

as Francis Huxley’s *The Raven and The Writing Desk* (1976).⁹³ Despite these attempts, the riddle will always technically remain unsolvable since no answer was thought at the beginning.

Absurdity continues in *Through the Looking-Glass and What Alice Found There* (1971), the poem “Jabberwocky” often being considered quintessential nonsense literature. Upon his arrival in the chess table, Alice finds a book that she assumes is written in a foreign language since she does not seem to be able to recognise any of the letters (Carroll, 1971):⁹⁴

.YKCOWREBBAJ

sevot yhtils eht dna, gillirb sawT

ebaw eht ni elbmig dna eryg diD

,sevogorob eht erew ysmim lla

.ebargtuo shtar emom eht dnA (p. 18).

Soon enough, she realises that it is a looking-glass book in mirror-writing, and she must hold it up to a glass to read it the right way. Even then, Alice is puzzled by the number of unknown terms she encounters, including “galumping” or “chortle”. These seemingly ancient and strange words might be included due to the fact that this poem is said to be inspired by English folklore, particularly the legend of the Sockburn Wyrn (Byghan, 2020), or the Lambton Wyrn in Northumbria, both ferocious dragon-like creatures that laid waste to County Durham. This is no coincidence, as Carroll’s emotional connections to Northern England and cultural inspiration increased due to his visits to his family: “The Walrus and the Carpenter”, for instance, is set in the beach at Whitburn, close to where his sisters Mary and Elizabeth lived in Sunderland.

93. Francis Huxley (1923–2016) was a British zoologist and anthropologist who also wrote some books about Lewis Carroll, including one about the author’s obsession with the properties of number 42 that remained unfinished upon his death (Napier, 2017).

94. From this point onwards, all the quoted pages of *Through the Looking-Glass* refer to the edition that is indexed in the references.

The revival of Northern England comes hand in hand with that of dead metaphors, which nowadays cease to surprise due to its passing into common usage and often go overlooked. Interestingly enough, objects that were once twinned in a metaphor become “reunited in a pun that yields a teasing example of nonsense” in *Alice in Wonderland* (Brown, 2013: p. 41). In chapter 2, “The Garden of Live Flowers”, the Tiger-lily says that in most gardens “they make the beds too soft—so that the flowers are always asleep” (p. 28), a reference to flower beds, garden plots in which flowers are planted. While the metaphorical content of this pun has been lost, it explains why Alice had not heard flowers speak before. Similarly, the prospective dinner courses for Alice and the White and Red Queen later in the book are removed as soon as they are presented, because “it isn’t etiquette to cut anyone you’ve been introduced to” (pp. 184–185). The leg mutton and plum pudding (which they would have to cut to eat them) become the conduit through which the literal meaning of a forgotten metaphor is applied figuratively.

The Queens are the source of many puzzling encounters and challenge Alice’s established way of thinking, who desperately tries to keep up with their pace and meet their impossible standards. The Queens are a tough crowd who will not take a wrong answer, but it seems that no answer pleases them. Claiming to have believed up to “six impossible things before breakfast” (p. 89), they seem unsatisfied with Alice’s approach to problems, both mathematically and linguistically. Upon reaching the eighth square on the chessboard in chapter 9, “Queen Alice”, the main character must be interrogated by both the Red and White Queen before becoming queen herself. Annoyed by Alice’s lack of knowledge towards negative numbers when doing subtraction—or perhaps an absurd solution that would match their inner logic—, they try to present this operation in a different form. Impatient when Alice hesitates after being asked to subtract a loaf from a knife and answering for her, they give her a third chance to take a bone from a dog. Unfortunately, even if Alice thinks outside of the box and considers these two elements as well as herself, who would presumably be bitten by the dog, her confident fails to impress the queens:

‘She can’t do Addition,’ the Red Queen interrupted. ‘Can you do Subtraction? Take nine from eight.’

‘Nine from eight I can’t, you know,’ Alice replied very readily: ‘but—’

‘She can’t do Subtraction,’ said the White Queen. ‘Can you do Division? Divide a loaf by a knife—what’s the answer to that?’

‘I suppose—’ Alice was beginning, but the Red Queen answered for her. ‘Bread-and-butter, of course. Try another Subtraction sum. Take a bone from a dog: what remains?’

Alice considered. ‘The bone wouldn’t remain, of course, if I took it—and the dog wouldn’t remain; it would come to bite me—and I’m sure *I* shouldn’t remain!’

‘Then you think nothing would remain?’ said the Red Queen.

‘I think that’s the answer.’

‘Wrong, as usual,’ said the Red Queen: ‘the dog’s temper would remain’ (pp. 170-171).

This enigma becomes just one of the many explored by Carroll, some of which have been included in this chapter, but whose extensive literary background makes it impossible to cover within a case study. For instance, some of his other word games include anagrams (producing new terms from existing words by changing the order of the letters and/or word divisions) and acrostics (a traditional device within a puzzle or a poem where the first letter of each line spells a word or a phrase). His continuous interest and practice of different types of enigmas equipped him with a set of problem-solving skills (Moktefi, 2018) that he used to create both literary and mathematical production, but that he could have applied to multiple situations in real life.

5.3. The Dominoes Cascade in a Line: Ada Lovelace's Contribution to the First Algorithm

At the beginning of the Victorian period, the examination for the mathematical tripos—a three-year or a four-year course equivalent to an undergraduate degree—was still the “Senate House examination” at Cambridge, which was regarded as the basis for a liberal education (Crilly, 2011). As one of the requisites for the young students, acquiring these mathematical skills as soon as possible was encouraged, since it was believed that learning them later in life could become an obstacle for a grown man. The knowledge of mathematics was useful in itself for those who intended to become tutors or professors and was also thought to help to develop and strengthen what Victorians called “the faculties of the mind”. After all, problem-solving and working effectively under pressure were all part of the university training for its students (Crilly, 2011). In other words, the successful acquisition of mathematical skills could be effective and have a practical application in any other field, as if mastering this art and toning the intellectual muscle would be a key to open every other. Women did not feature in these plans, coming onto the Cambridge scene only in the 1880s.

It was not until 1868 that the University of London admitted six women to study at the institution, denying access to information and relegating them to the domestic space. This institution became the first university in the (now) UK to accept women on equal terms with men and award degrees to female students a decade later⁹⁵ (Hartmann, 2015). While British universities progressively opened up the academic space to women, the first foundation of the Ladies College in Bedford Square by Elizabeth Jesser Reid⁹⁶ dates back to 1849 (Oldfield, 2023). At the time, the college was thought to hold a radical vision since their intention intended to go beyond vocational training for future governesses and

95. For more information about this, there are a wide range of available papers and archive collections on the UCL (University College London) website, as indexed in the references.

96. Reid [née Sturch], Elizabeth (Elisabeth) Jesser (1789–1866) was the founder of the first college for women in the UK, who used her independence income to help the abolitionist and feminist movements in the country (Oldfield, 2023).

actually widen women's horizons. This was not the average decision at the time and women's access to higher education was to experience several bumps until they were granted the same possibilities as their male counterparts.

There were serious restrictions that would limit the number of accepted women significantly or not allow them to get an award despite having completed their studies, awarding them instead with a "Certificate of Proficiency" (Harte, 1986). There would still be a long way to go towards the full acceptance of female students in the 20th century, including for ancient well-known universities such as the University of Oxford in 1920, where the first day was remembered as exciting for the future of women by its female professors and students (Brittain, 1960). According to the official website from the University of Cambridge, Emily Davies had already established Girton College as the first in the UK to offer residential higher education for women but was the last British university to grant degrees to women in 1948 (n.d.). Albeit their lack or restricted access to regulated education, some women who belonged to middle- and to upper-class background had resources to pursue education in other ways—and successfully change history for the better, such as Ada Lovelace.

Born in 1815 in London, Ada Lovelace (also known Augusta Ada King, Countess of Lovelace, née Byron) was taught at home like any other woman in her position and time would. Daughter of Lord Byron,⁹⁷ he believed in a "reward and punishment" system, even if Ada's full dedication to her studies sometimes became an issue due to her suffering from a recurrent illness (Hartmann, 2015). Since their parents got separated early on and her father died promptly, her mother Lady Byron and some tutors such as Sophia de Morgan,⁹⁸ whom she spent most of

97. Lord Byron (1788–1824) was as an English romantic poet and novelist who became one of the leading figures of the Romantic movement (Douglass, 2004).

98. Sophia de Morgan (1809–1892) was an English writer and activist for the rights of women who tutored Ada and would be later on impressed by her understanding of the Analytical Engine when introducing her pupil to her husband Augustus de Morgan (Charman-Anderson, 2020).

her time with, structured her classes. She hoped that Ada would have an overall view of what she considered to be the most important subjects, including astronomy and foreign languages. Ada complained about her mother's resistance to learning literature and philosophy, since rationality and emotion belonged to the same sphere in her head, acknowledging "intuition, logical thinking, and concentration (...) as the basis of any scientific-creative work"⁹⁹ (Hartmann, 2015). This holistic approach to knowledge would help later on to be ahead of her time, considering both the linguistic and mathematical implications of machines.

Since Ada was 13 years old, she began to wonder beyond the formulae of mathematical rules and inquiring about the whys or hows, as opposed to sticking to memorising numbers and symbols with no deeper understanding of the way they worked (Hollings et al., 2017a). Ada was soon introduced to Mary Somerville,¹⁰⁰ who was not only her tutor but a good family friend due to her and Ada's mother common interest in mathematics (Pohlke, 2015). Somerville included basic trigonometry and cubic and quadratic equations in her teaching, taking a newer analytical approach based on continental mathematics (Hollings et al., 2017b). Ada carried on studying calculus and higher mathematics with Sophia's husband, Augustus De Morgan,¹⁰¹ with whom she maintained a large volume of correspondence. This is available upon request through the Special Collections items at the Bodleian Library in Oxford.¹⁰²

99. Original text: „Emotion und Vernunft gehörten für Ada Lovelace zusammen. Intuition, logisches Denken und Konzentration erkannte sie als die Säulen ihres wissenschaftlichen-kreativen Arbeitens.“ (Hartmann, 2015) (Author's translation).

100. Mary Somerville (1780–1872) was a Scottish scientist and writer who had a traditional education for a woman of her status. Later labelled as the “queen of science” due to her major contribution to this field such as with *On the Connexion of the Physical Sciences* (1834) or *Physical Geography* (1848), she was elected as the first female Honorary Member of the Royal Astronomical Society along with German astronomer Caroline Herschel. She was also an activist for women (Pohlke, 2015).

101. Augustus de Morgan (1806–1971) was a British mathematician and logician whose contributions include De Morgan's laws as rules of inference. He tutored Ada Lovelace for 18 months around 1840 (*Britannica*, 2023a).

102. Please note that, at the time of this thesis, this service is only available to researchers (including PhD students) from any British university that possess a reader's card and request the items in advance. To get a reader's card, the user needs to fill in an application

A significant part of this correspondence revolves around De Morgan confirming or correcting Ada's solutions to the mathematical problems she was given and shows the continuous practice that she went through over the years to polish her problem-solving skills.¹⁰³ That is, the learning method consisted of guided independent reading followed by a series of pertinent problem exercises. At first, his pupil seemed baffled by some of his suggestions, which she did not completely understand. With some practice, Ada had enough foundational knowledge in algebra and trigonometry to delve into calculus, the area in which she was the most interested.

When writing to Lady Byron and addressing her daughter's abilities, De Morgan stated that the power of thinking and her ever-need to go beyond the bounds of knowledge that Ada had always shown from the beginning through their correspondence was uncommon for any person regardless of their gender or expertise. Had she been a male student, De Morgan insisted, she could have been an original mathematical investigator, perhaps a first-rate eminence (Hollings et al., 2017b). After one and a half years, their correspondence stopped, which seemed to mark the end to Ada's formal mathematical education. Then it was time for her to apply her knowledge to real-life matters—which she would carry on doing with barely any breaks until her death at 36 years old.

Once Ada gave birth to her three children, she resumed her mathematical studies in November 1839 and got back in touch with Charles Babbage¹⁰⁴ (Hartmann, 2015). In his autobiography, Babbage stated his opinion on several topics including ciphers, where he thought that there was “a kind of maxim amongst the craft of decipherers (similar to one amongst the locksmiths), that every cipher can be deciphered”, even if people held

form and bring all the necessary documents to the admissions office at the Weston Library prior to consulting the items.

103. All the information about the correspondence between Augustus De Morgan and Ada Lovelace has been consulted by the author herself on November 23rd, 2023, at Weston Library in Oxford, upon previous request through the Special Collections website.

104. Charles Babbage (1791–1871) was a British polymath who invented the first mechanical computer, the Difference Engine, although many of his projects remained undone upon his death (Dubbey, 1978; Hyman, 1982; Swade, 2001).

the strong conviction that they could create one that remained inscrutable (Babbage, 2020 [1864], line 174). His engineering work reflected this viewpoint, creating machines from scratch that would serve as the beginning for modern-day computers (Dubbey, 1978). Ada was very much inspired by him, a mathematician that had developed a mechanical machine—more specifically, a project that involved an automatic calculator. It was intended to solve polynomial functions such as squaring and cubing numbers or even tabulating the root of a quadratic equation.

This design was called the Difference Engine: when Ada and her mother, lady Byron, were invited over to his house and saw a glimpse of his prototype, the youngest was mesmerised at how complex calculus became simplified through its usage (Essinger, 2015). Ada studied Babbage's engineering drawings, the undertaking of which were cost-effective, but still too expensive even for a wealthy man like Babbage (Hollings et al., 2017a). Thus, the mathematician needed to write to the government to ask for financial aid (Hyman, 1984). While his innovative machine is nowadays simply known as calculator, he made a major contribution to computer science. He anticipated how computer memory and processors would work by drawing a distinction between two places within the same machine: one where variables would be stored, and another one where mathematical operations would be carried out (Strawn, 2023).

By early 1841, Ada had already built the habit of going beyond the examples in the textbooks that De Morgan gave her and had been actively trying to develop her own proofs by the beginning of 1842 (Hollings et al., 2017b). This attitude reflected a greater mathematical maturity from Ada's side, whose questions became more sophisticated upon acquiring a solid grounding in several areas of what then university-level mathematics was. Her reluctance to make generalisations and her critical thinking towards underlying principles showed her ability to make perceptive and far-reaching observations, which would become the basis of her participation in the draft of the Analytical Engine.

Figure 10

Ada's draft

[illegible]

Note. This well-known table is not a specification for a card deck to compute the Bernoulli numbers, but a complete simultaneous view of all the successive changes that the Analytical Engine would go through when computing a specific number. When computing other Bernoulli numbers, the engine would perform different sequences of operations, leading to tables with more or fewer rows (Haigh & Priestley, 2015). This picture was taken by the author from the copy available of Taylor's *Scientific Memoirs* (1843) at Magdalen College, University of Oxford.

Between 1842 and 1843, she translated Luigi Menabrea’s article on Babbage’s Analytical Engine (originally written in Italian, *Notions sur la Machine Analytique de M. Charles Babbage*), which she published in Taylor’s *Scientific Memoirs* (vol. 3) along with an elaborate set of notes (Strawn, 2023). The translation was published anonymously, and her notes credited her with her initials “A.A.L.” (Lovelace, 1843). The machine was originally Charles Babbage’s Analytical Engine, but Lovelace’s instructions—which could now be understood as a computer programme—was meant and is believed to have calculated the Numbers

of Bernoulli (Charman-Anderson, 2020). Bernoulli's theorem was considered the watertight proof of the existence of constant causes by many mathematicians and statisticians, a significant advancement in the world of numbers (Kılıc, 1999).¹⁰⁵ While Babbage had also worked on them, Lovelace was in charge of most of the elaboration and discovered an error in Babbage's development that was later fixed (Hartmann, 2015).

Much controversy has surrounded Ada's contribution to the machine, partially due to a misdating of letters and a misunderstanding of how her education unfolded (Hollings et al., 2017b). Due to the times and expectations surrounding the academic culture, Lovelace's ideas and intellectual views were suppressed compared to those of her male peers, as a woman was not believed to be as capable of conducting research as a man (Stein, 1985). In his 1950 paper, even Alan Turing challenged Ada's view on the limits of a computer's processing power because he found it too avant-garde, naming it the "Lady Lovelace's objection" (1950). Not only were her contributions questioned—and sometimes even mocked—at the time, but they also kept being discussed to recent years, some scholars claiming that she was never the great mathematician that she is claimed to be or even that historian researchers could not conclude that there had been any substantial influence of Babbage on the engineering of early computers (Haigh & Priestley, 2015).

The history of women's role in computer science and information technology is complicated to summarise and assert. Due to the cultural expectations of their historical context, they were relegated to a secondary position and were devalued as female digital pioneers (Blair, 2019). Crediting only Babbage as the father of computing made it difficult for Ada's name to stand out as much, her mathematical ability being questioned to the point where some ideas on the papers that she had wrote—evidenced by her handwriting—were doubted to be hers. Even if Babbage had passed on the entire formula to Ada, an algorithm is *not* a programme (Krämer, 2015; Hollings et al., 2017). This programme

105. Jacob (1655–1705) and Johann Bernoulli (1667–1748) were two mathematicians who spent much of their life polishing and expanding the calculus, and their great contributions to the discipline include the constant e (also known as Euler's number) (Tent, 2009).

was one of the most—if not the most—complex that they had done to date, and its system resembles the principles and structure of modern programming. Thus, Ada must have developed the instructions on her own.

An algorithm, with which Babbage helped the most, is not yet a programme: albeit necessary for its development, it does not meet the minimum requirements for programming. Algorithms are the raw material for programming, similar to the baking ingredients for a lemon drizzle—which, if not combined in the right order and bearing in mind the right amount for each, will not get to the cake stage. In order to speak of a real programme in the technological sense, there needs to be a machine with a series of tasks that it can perform: algorithms are no other than the set of rules that are converted into machine-readable programmes (Krämer, 2015). These become a sequence of instructions that said machine can take as the instructions (input), read and deliver a result (output).

Although she had never disliked mathematics, Ada's interest rocketed when being presented with the Analytical Engine, Babbage's next project (Hartmann, 2015). For her, calculating engines were not the beginning of the information revolution, but rather an attempt to finally bridge reality and the world of ideas, to ultimately build the link between the spiritual and the material that could enable grasping the physical world (Forbes-Macphail, 2013). Ada knew how to link the abstract world of mathematics to practical applications in the real world, and her manuscripts would later recognise the potential of computers to go beyond simple calculations. In other words, her ideas helped to establish the foundation for what computers would become. Babbage was just as adamant that mathematics had to allow practical, real-life applications, haunted by the idea that unskilled computers could be eventually taken over by machinery. For these ideas, he went miles, including the development of a new algebraic system that described the movement of the interconnected parts of the machine (Bowden, 1953).

Since invention or discovery takes place by combining ideas so that they meet specific requirements or are in some way useful to a specific purpose, it is very likely that Ada was able to combine her previous

knowledge of mathematics by practising with Charles Babbage on his analytical engine and its potential applications as a general-purpose computer (Robertson, 2016). In Note A of her translator's notes on *Art XXIX.-Sketch of the Analytical Engine invented by Charles Babbage, Esq..* Ada begins with an introduction to the ever-need for human knowledge, and how she found that going beyond the boundaries strengthened one's mind (Lovelace, 1843):¹⁰⁶

Those who view mathematical science not merely as a vast body of abstract and immutable truths, whose intrinsic beauty, symmetry and logical completeness, when regarded in their connexion together as a whole, entitle them to the prominent place in the interest of all profound and logical minds, but as possessing a yet deeper interest for the human race, when it is remembered that this science constitutes the language through which alone we can adequately express the great facts of the natural world, and those unceasing changes of mutual relationship which, visibly or invisibly, consciously or unconsciously to our immediate physical perceptions, are interminably going on in the agencies of the creation we live amidst (p. 696).

In this extract, Ada shows the practical application of mathematics, and how useful they can be to the general public as opposed to a handful of professionals in the field. Through drawing up patterns and establishing relationship between two seemingly unconnected things, this very process is the essence of problem-solving: being able to store knowledge and put it into use it in other areas. In Note G, Ada acknowledges some risk when doing so, since this process necessarily involves induction. When considering objects from different perspectives to solve a specific problem, the speculation over what they might become is subject to change upon confirmation of a hypothesis. Sometimes, those speculations

106. From this point onwards, all the references to the notes belong to the edition of Taylor's *Scientific Memoirs* that is indexed in the references, which is the one the author consulted at Magdalen College in Oxford. All italics are Lovelace's.

are never tested, and a hypothesis is ruled out before getting confirmation, moving on to test the next one:

For, in so distributing and combining the truths and the formulae of analysis, that they might become most easily and rapidly amenable to the mechanical combinations of the machine, the relations and the nature of many subjects in that science are necessarily thrown into new lights, and more profoundly investigated. This is a decidedly indirect, and a somewhat *speculative*, consequence of such an invention (p. 722).

Rather than relying on talent, fate or magic, developing problem-solving skills means being able to articulate what difficulties stand between the problem and its solution and learn to overcome them. Ada's errors had reduced significantly after being tutored by De Morgan, her attitude also changing under his supervision. In their letters, Ada was eager to learn as much as she could, and seemed rather frustrated due to the limits of the human brain given how much knowledge was left to grasp and how little progress she thought that she was making. Since her correspondence with De Morgan, Ada had learnt to acquire better habits of study, including going over the exercises more slowly and learning from mistakes, and adjusting her learning expectation to what could be achieved in reality (Hollings et al., 2017b). Her mind had been constantly engaged in the practice of investigation, accustomed to rigorous and exact research (Natale & Henrickson, 2022), and was more open to trial and error every day. She found non-completed projects and mistakes useful, since they provided explanations to what was wrong, even if she did not know yet how to make it right.

In Note G, her previous frustration due to her learning pace turns into patience and a determination to draw patterns beyond the strict categories of "success" and "failure". When the Analytical Engine succeeded the Difference Engine, Lovelace questions whether the amount of effort that was put into the latter for it to never be finished was a waste of time. The progress on this machine had been suspended for a long time, and Lovelace was convinced that the development of the first machine had a

practical application on the new one:

We leave it for the decision of each individual (after *he has possessed himself* of competent information as to the characteristics of each engine), to determine how far it ought to be a matter of regret that such an accession has been made to the powers of human science, even if it *has* (which we greatly doubt) increased to a certain limited extent some already existing difficulties that had arisen in the way of completing a valuable but lesser work (...) These persons being likely to possess but little sympathy, or possibly acquaintance, with any branches of science which they do not find to be *useful* (according to *their* own definition of the word), may conceive that the undertaking of that engine, now that the other one is already in progress, would be a barren and unproductive laying out of yet more money and labour; in fact, a work of supererogation (p. 699).

From her point of view, the results that they had obtained to date were coupled with other possible applications that were yet to be foreseen. Note how Ada thinks that the reader can only judge the situation should they have enough information about how the engine works, which is intrinsically related to evaluating data when approaching a problem. She encourages the reader to take a step back and see the experience that they gained through the study of the first machine as something that could serve as useful data for something else.

Explanations are like keys to locked doors, being stored in memory by the brain in hopes that they might help to understand input and how this differs from what was expected from previous experiences (Anderson et al., 2004). If a failure of an action is detected—that is, an action develops in a way that does not meet our expectations for similar situations—that unexpected outcome is recognised and remembered. This way, more information is available for next time and the solver will be able to make a more nuanced judgment that can prevent an expectation from failing to materialise (Schank, 1982). The consistency of failures is reminded by

the brain because memories are indexed in terms of their relationship to previous processing attempts, allowing the creation of better expectations. Enhancing learning depends on failure, failure depends upon prediction and prediction relies on the initial classification of the objects and events that have been encountered before (Schank, 1982).

This base to learn upon is what Ada describes in Note G, where she refuses to treat the machine as being capable of doing magic, but rather as a way of simplifying the Bernoulli numbers¹⁰⁷ upon being given a set of instructions. She includes a description of the method as well as a diagram of a highly complex calculation of the Bernoulli number sequence, for which an algorithm is needed, but reducing it to a command for the machine to execute. Such concise information would have sped up the calculation significantly, an essential task when performing problem-solving: reducing the number of steps without compromising the quality of the result.

It is interesting to observe, that so complicated a case as this calculation of the Bernoullian Numbers, nevertheless, presents a remarkable simplicity in one respect; viz., that during the processes for the computation of millions of these Numbers, no other arbitrary modification would be requisite in the arrangements, excepting the above simple and uniform provision for causing one of the data periodically to receive the finite increment unity (p. 729).

Similar to its precursor, this machine is considered one of the earliest prototypes of modern computers, since it included separate components for processing and memory. Unlike the previous one, however, it went beyond arithmetic formulas to perform algebraic operations through punched cards. These were chunks of stiff paper which represented pieces of digital data through the existence or absence of holes in predefined positions. The results were being printed out simultaneously based on the

107. Bernoulli numbers are a sequence of rational numbers—that is, numbers that are expressed as the quotient or fraction of two integers, where the denominator should not be equal to zero—which occur frequently in analysis, often also appearing in the expression of sums of a fixed power of consecutive integers (Ribbenboim, 2001).

principle of successive orders of differences (Essinger, 2015). Comparing its process with the weaving of flowers and leaves, Ada found that the machine was as programmable as the looms using the punch cards.¹⁰⁸ In other words, the fact that the solutions that the machine provided were given in numeral notation does not mean that said operations were limited to a numerical level, but rather than its main purpose was managing to simplify operations. Though incredibly useful—and avant-garde to some extent—, both Ada and Babbage acknowledged its shortcomings.

As stated earlier in the chapter, the machine could not anticipate relations between said operations, let alone establish or even solve theoretical questions that might arise in the process. In other words, it could only perform what it was previously instructed to do. Ada insists on warning the reader about how overconfident someone might be when assessing the importance or scope of something beyond its limitations, which can be detrimental to the outcome. A lack of judgement might turn an initially promising project into a subjective perspective of the matter, which is highly unlikely to deliver as expected in the long run:

In considering any new subject, there is frequently a tendency, first, to *overrate* what we find to be already interesting or remarkable; and, secondly, by a sort of natural reaction, to *undervalue* the true state of the case, when we do discover that our notions have surpassed those that were really tenable (p. 722).

The list of operations that the Analytical Engine performed would be later similar to those stated by Alan Turing as necessary for any general-purpose digital computer of the modern era (*Britannica*, 2023g).¹⁰⁹ Albeit

108. Though the understanding of how punch cards work is not essential for this chapter, these have been used for the operation of machinery from the early 19th century, initially to control the threads and produce a specific pattern. In computer programming, these card stocks store digital data (Heide, 2009).

109. These operations include: algebraic addition, algebraic subtraction, algebraic addition with n^k figures, algebraic subtraction with n^k figures, ascertaining if a variable is zero, ascertaining if a variable has a + or - sign, reversing the accidental sign of a variable, stepping up or multiplying any number by 10^n , stepping down or multiplying any number by 10^{-n} , counting number of digits in variable and sending it to store, differences and

a huge advancement in the industry, Ada also included exceptions to its use, which again go back to the risk of inference, even if a rule *generally* works for the machine:

We may here remark that the average estimate of three Variable-cards coming into use to each operation, is not to be taken as an absolutely and literally correct amount for all cases and circumstances. Many special circumstances, either in the nature of a problem, or in the arrangements of the engine under certain contingencies, influence and modify this average to a greater or lesser extent (p. 730).

Considerable further work would be required to turn the calculation described by the table into a set of cards that the Analytical Engine could read to calculate all the Bernoulli numbers. Computing machines had to wait until the 20th century, when electromechanical and electronic technologies took over the merely mechanical technology that had been available to date (Haigh & Priestley, 2015). Far from being limited by her time and resources, Lovelace recognised that any machine capable of manipulating numbers could also manipulate symbols, separating it from mere calculating machines (Charman-Anderson, 2020). Furthermore, she represented how numbers could represent entities other than quantity marks, which helped to initiate the fundamental transition from calculation to computation (Krämer, 1988).

Doubting Ada's expertise is thought to say more about society's reluctance to see women as pioneers and the undermining of women's achievements as well as their historical impact than about computing itself (Charman-Anderson, 2020). She believed that "in all extensions of human power, or additions to human knowledge, various collateral influences, besides the main and primary object attained" (pp. 722–723), which reflected the main spirit of problem-solving and her approach to learning. Through the development of these skills, she was able to apply previous information to new challenges and draw a draft of what an algorithm could look like.

multiplication without a table (Babbage, 1843).

5.4. Being a Mastermind: Problem-Solving in Bletchley Park

The death of the queen Victoria marked the end of the longest reign in British history at the time and the Victoria Era in 1901, although this period is also said to roughly end at the beginning of the WWI in 1914 (Steinbach, 2023).¹¹⁰ By the Edwardian era, women were working beyond factory work or domestic service. The 1901 census recorded lawyers' clerks, physicians, dentists and dental assistants, and during the period there was also a marked rise in women becoming teachers—in 1902, for instance, Lancashire and Cheshire textile factories employed 289,000 women and 181,000 men (Rosen, 2013). As middle-class women rose in status and increased literacy enabled them to have a wider access to resources and form their own ideas, The Women's Social and Political Union (WSPU) was founded in 1903. Its members, though by no means the first in the UK's history to organise a campaign for the feminine vote, were coined as “suffragettes” by a Daily Mail reporter in 1906, thus becoming the First Wave (Purvis, 1995). The Criminal Investigation Department of New Scotland Yard reported another demonstration by this society a few years later at the Hampstead Town Hall that participants were asking not to be classified as “isolated acts of hysterical women” (*Metropolitan Police*, 1913).

Emmeline Pankhurst¹¹¹ delivered the “Freedom or Death” speech in Hartford, Connecticut in 1913, stating that “If we win it, this hardest of all fights, then, to be sure, in the future it is going to be made easier for women all over the world to win their fight when their time comes” (Pankhurst, 1913). During that same year, the 1913 Prisoners (Temporary Discharge for Ill-Health) Act—also commonly known as “the Cat and Mouse Act”—was passed due to the number of imprisoned suffragettes, including Pankhurst, that endured hunger strikes as a form of protest and

110. A major part of the sources for this case study were drawn from my meeting with Dr. David Kenyon at Bletchley Park on November 15, 2023, as well as my visit to the facilities, hence the seemingly fewer literary references. Dr. David Kenyon is a research historian for the Bletchley Park Trust, the Second World War code-breaking site in Milton Keynes, Buckinghamshire. As an expert and therefore reliable source in the field, he spent two hours with the author going over the role of problem-solving within Bletchley Park.

111. Emmeline Pankhurst (1858–1928) was the leader of the militant wing of the movement.

whose lives was at risk (Atkinson, 2018; Pankhurst, 2020 [1915]). Non-violent suffragettes would also regularly hold meetings under feminist mottos such as “Better is Wisdom than the Weapons of War” in Hyde Park (*The Illustrated London News*, 1913). Members of these societies would employ fake names and secret codes to communicate and organise the meetings—which would then be used in the conspiracy trials against WSPU leaders—as provided by *The National Archives*, the official archive of the UK government. These included Selina Fry for Miss Stella D. Fife or Miss Laura Grey for Miss Lavender Guthrie (Figure 11) as well as code words such as “Platinum” for Waterloo or “Mixture” for “Letter follows, do nothing until you hear again” (Figure 12 and 13).

Figure 11

Fake names employed by suffragettes

FICTITIOUS NAMES		Ex. 126 (Contd.)
Albert, Miss Sophia	Real name	Mrs. Margaret Bennett
Bennett, Dorothy	" "	Miss D. Barnwell
Black, Miss Norah	" "	Miss Nellie Blackledge
Bowen, Mrs.	" "	Mrs. E. Bodell
Brown, Kate	" "	Miss Katherine Blackledge
Callum Emmeline	" "	Miss Maude Mac Callum
Campbell, Mrs.	" "	Mrs. L. Galway
Chatt, Mrs.	" "	Mrs. Chatterjee
Dew, Miss Margaret	" "	Miss Ingledew
Edwards, Mary	" "	Miss Selina Martin
Fry, Selina	" "	Miss Stella D. Fife
Green, Janet	" "	Miss Rebecca Hyams
Grey, Miss Laura	" "	Miss Lavender Guthrie
Harley, Frances	" "	Miss Florence Harris
Hodgkinson, Miss	" "	Nurse Hutchinson
Hotham, Miss Jane	" "	Miss Brenda Franklyn
Johnson, Mrs. Sarah	" "	Mrs. Alice Dilks
Leland, Audrey	" "	Miss Gwen Pryce
Ley, Miss Ethel	" "	Mrs. Edith Annie Lees
Mickle, L.E.	" "	Miss S.E. Tuequand
Mitchell, Heather	" "	Miss Dorothy Hartopp Radcliffe
North, Miss Mabel	" "	Miss Mabel Norton
Nugent, Mrs.	" "	Mrs. Avery
Reynolds, Mrs. Margaret	" "	Mrs. Winifred Reinold
Rice, Miss Helen	" "	Miss H. B. Hanson
Pilkington, Miss Katherine	" "	Miss Alison Graham
Slade, Miss Ethel	" "	Miss Ella Stevenson
Stuart, Miss Grace	" "	Miss Geraldine Phyllis Stevenson
Stuart, Jane	" "	Miss Ethel Seymour Bennett
Taylor, Evelyn	" "	Miss Evelyn Hannah Cheshire
Woolridge, Mary	" "	Miss Edith Pridden
Summers, Mrs.	" "	Mrs. Bach, Grosvenor Rd.

Figure 12

Secret communication between suffragettes

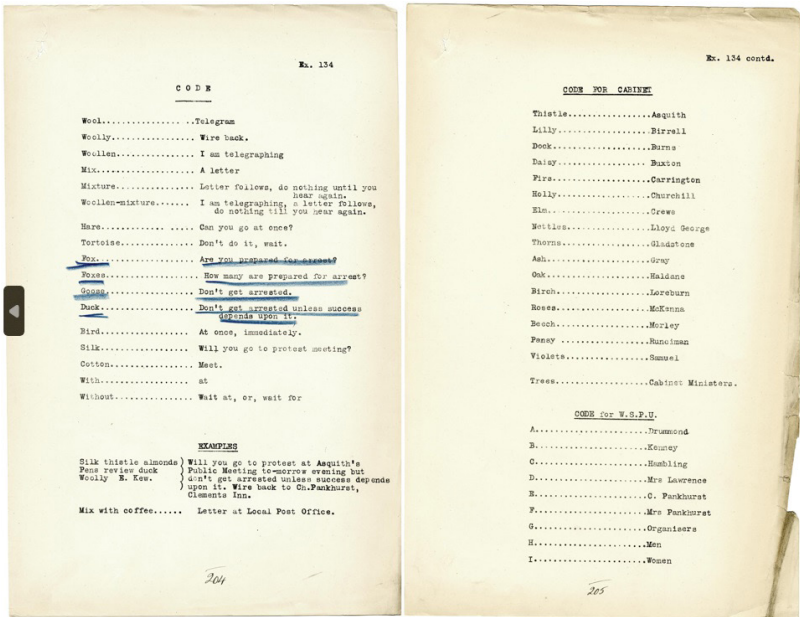
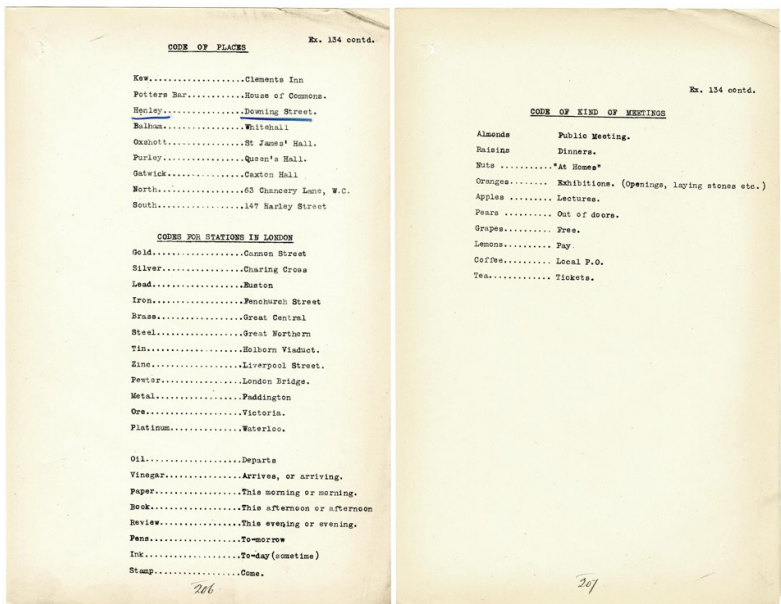


Figure 13

Secret communication between suffragettes



Cryptography was nothing new: coined from two Greek words “Krypto”, “graphein”, meaning “hidden” and “writing” respectively (Ghosh et al., 2020). This discipline had a history leading back at least to the 9th century, where the Bayt al-Ḥikmah or House of Wisdom (originally بيت الحكمة), an Abbasid public academy and research centre in Baghdad (Al-Khalili, 2011), attracted scholars from various areas of knowledge to the capital. As one of the leading libraries during the Islamic Golden Age (Algeriani & Mohadi, 2017), many renown scholars did participate in the meetings, and Persian polymath al-Khwarizmi¹¹² wrote the first book that classified algebra as an independent mathematical discipline (Rashed, 2001). Though there is very little historical information available (Gutas, 1998), the earliest surviving document on cryptology, *A Manuscript on Deciphering Cryptographic Messages* (841), was written within the building by philosopher and mathematician Al-Kindi,¹¹³ the first director of the Library and Translation Academy at the Bayt al-Ḥikmah.

Relative frequency analysis—or how to interpret the frequency of letters in order to solve an encoded message—was portrayed for the first time in this manuscript (Broemeling, 2011). Al-Kindi explained how inferring the meaning of a cipher was easier when estimating the relative frequencies within a cryptogram by matching them to the frequencies of the source language—in this case, the Arabic alphabet—. He acknowledged that these equivalences did not apply to short texts, given that the number of letters was too low.

The invention of the telegraph in the mid-19th century had attempted to stimulate cryptography but had fallen well short of generating a revolution. Most encryption was limited to a handful of code books, the codes being constituted of a few words a minute in the best-case scenario, and not very securely (Reeds et al., 2015). The 20th century

112. Abu Jafar Muḥammad ibn Mūsā al-Khwārizmī (783–ca.847) established himself as a leading scholar of Khorezm at the House of Wisdom, contributing massively to the study of algebra and arithmetic (Aksoy, 2016).

113. Abū Yūsuf Ya‘qūb ibn ‘Ishāq aṣ-Ṣabbāḥ al-Kindī (801–873) was a polymath who encouraged the idea that mathematics should be used as an essential tool for the analysis and research of Philosophy (Tahiri, 2014).

experienced an additional security measure applied to messages which marked the beginning of modern cryptology, especially those which were already protected by the careful handling of diplomatic pouches. The use of wireless telegraphy during WWI encouraged the creation of more complicated codes which eventually led to the development of machine cryptography (Dooley, 2013).

Just like the rest of the countries involved in the conflict, the nation was in a rush to get as many ways of coding as possible. Hence, the foundation of Room 40—also known as 40 O.B—as the British cryptanalysis section during WWI (Greenberg, 2017). Located on the first floor of the main wing of The Admiralty's Old Building on Whitehall road in Central London, their operations involved naval codebooks such as *the Signalbuch der Kaiserlichen Marine* (SKM) and the Imperial German Navy's *Handelsschiffsverkehrsbuch* (HVB). Additionally, there were some maps (containing coded squares) that the Russian allies had passed on to the British Admiralty after keeping two of the three copies that they had captured for themselves (Farquharson-Roberts, 2014). Protecting British Government communications and decrypting messages sent by foreign countries were the main functions in Room 40, which is estimated to have intercepted and solved around 15,000 German secret communications between October 1914 and February 1919 (Kahn, 1973).

Even though most of the history of the beginning of the British Signals Intelligence in WWI revolves around the work of Room 40 in the Admiralty, it was an intelligence section in the War Office—the MO5b, later renamed as MI1(b)—which was successful against German codes for the first time (GCHQ, 2016). Intelligence was similar to the method employed by Sherlock Holmes in the sense that it involved sitting quietly, reviewing known facts and sorting out significant from insignificant and arriving at a solution by the exercise of judgement (Millward, 1993). The interception of German radio traffic was thought to advantageous by anticipating German plans, since European armies assumed until 1914 that most communications would be based on either telegraph, telephone or despatch riders (Greenberg, 2017). Thus, the development of effective cryptographic systems which employed wireless radio with an acceptable

level of security was not thought of by any army.

By 1915, however, all German communications which were subject to interception were read and circulated among Room 40 (Greenberg, 2017). Within a year of the end of WWI, the naval and military intelligence organisations—that is, both Room 40 and the British Army’s intelligence unit MI1b—had merged into one to become the Government Code and Cypher School (GC&CS), a peacetime cryptanalytical unit established in 1919 (Birch, 2004). Now known as Government Communications Headquarters (GCHQ), this institution is the UK’s intelligence, security and cyber agency. It is responsible for supplying signals intelligence and ensuring information security for the government and armed forces of the UK, a set of priorities that were established by the National Security Strategy as well as supported by the decisions of the National Security Council and the Joint Intelligence Committee (GCHQ, n.d.).

The higher the volume of the traffic sent by radio, the more urgent it was for the machines to perform the encryption and decryption of messages, which made this secret way of communication easier for employees and quicker for the country. The renowned cryptographic German machine, Enigma, made its debut in the 1920s, subsequently followed by iterations from various nations, such as the British “Typex” and the North American “Sigaba” (Kahn, 1973). The Admiralty refused to use Typex at first, presumably because signals encrypted by this machine were unpractical in ship-to-shore communications because they took longer to transmit than those that were based on a code book (Dear & Foot, 2014). As a result, a number of high-grade codes and ciphers were decoded by the German Navy’s *B-Dienst*¹¹⁴—the German naval cryptanalysis service, which resembled room 40. British naval shore commands were equipped with Typex machines by January 1943.

Germany had a long history of being successful in attacking Hagelin Machines, a Swiss manufacturer of cryptographic equipment founded in 1952 by Boris Hagelin as the successor to A.B. Cryptoteknik in

114. *B-Dienst* stands for *Beobachtungs-Dienst* in German, translated into English as “Observation Service”.

Stockholm (Hagelin, 1979). Though never actually used aboard British warships, Typex proved to be a decent version of Enigma since it had seven wheels and therefore they believed it to be “more secure than our enigma” (Ferris, 2007: p. 165).

Among many methods, the encryption of messages included Morse code, a system in communication which involves the usage of short and long signals (dots and dashes, respectively) to represent letters of the alphabet, numerals, and punctuation marks and is “transmitted as electrical pulses of varied lengths or analogous mechanical or visual signals, such as flashing lights” (*Britannica*, 2023c). Enigma machines, for instance, did not transmit messages, so this language was needed for a cipher clerk to write down each letter that would appear enciphered on a lighted panel upon setting the machine accordingly. Similarly, the cipher clerk on the receiving end needed to interpret the Morse code and set up the second machine in the same way so that the intended message also appeared on the lighted panel.

Even before hostilities began, a group of Polish mathematicians led by Marian Rejewski¹¹⁵ had already obtained results on how to attack Enigma and had shared their work with the French and the British, without which reading Enigma traffic would have not been possible by the time WWII broke out. There were periods of time where no traffic could be read (Reeds et al., 2015), but most information was intercepted in the early part of the war by the British cryptanalysts in Bletchley Park.

This GCHQ unit was to experience multiple changes between wars but would become the most relevant during the next major conflict in which the UK would be involved in: WWII. In 1938, the unit was transferred to Bletchley Park, a Victorian country house in Buckinghamshire (now Milton Keynes). This location was conveniently close to the railway services to the main Southern cities such as London, Cambridge or Oxford as well as large telephone cables (Reeds et al., 2015). Travelling

115. Marian Adam Rejewski (1905–1980) was a Polish mathematician and cryptologist who reconstructed Enigma messages until 1940, when extra security procedures were introduced (Inman, 2020).

between London and Bletchley was essential “as it remained the midpoint of the tracks between Oxford and Cambridge”, where many codebreakers were recruited (Christensen & Galdelfter, 2008: p. 23). Furthermore, it was a quiet and secure base already vacant that was easy for the government to take over. For three weeks, there were 70 employees in the mansion, eventually making it hard to concentrate with mounds of papers chaotically scattered around, but still not being enough people to do everything. In addition, methods like the Playfair cipher had been completely broken down by the German team by 1915, so there was an urgent need for a higher level of security.

Bletchley Park started then to work like a factory production line upon their return in 1939, where techniques were taken down to production-line tasks to be distributed among the employees. These processes included “emendation, translation, evaluation, commenting and signal drafting” (Millward, 1993: p. 20). Different approaches were needed to break the codes and ciphers, so specific enemy nations and communication systems were distributed within different teams such as The Watch. They were responsible for determining the priority of messages requiring transmission to codebreakers and identifying the intended recipients. In offices across Bletchley Park, the Indexers wrote down everything that was learnt about the enemy in lists and cards that would be carefully labelled and stored so that the information consistently grew. All the high-level decryption of enemy radio and teleprinter communications by British military intelligence was designated as Ultra, since it was considered to be even more important than the highest British security classification (Most Secret).

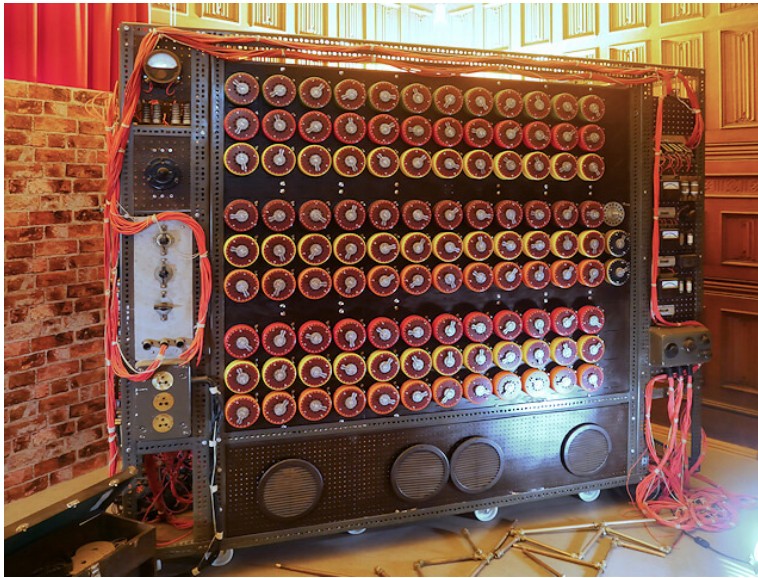
Bletchley Park marked the birthplace of the British Bombe, a large electromechanical device designed by cryptologists in the UK during WWII (Raikar, 2023). As more cables and rotors were added to Enigma, Alan Turing¹¹⁶ developed this device to meet the increasing number of

116. Alan Turing (1912–1954) was a British cryptanalyst and mathematician highly influential in the development of computer science, whose major contribution in Bletchley Park enabled the deciphering of an increasing number of codes (Cooper & Van Leeuwen, 2013).

possible encryptions, which went to 103,325,660,891,587,134,000,000 possibilities for each Enigma key at the outbreak of WWII. The Bombe solved the plugboard problem, since the 10 cables affected 20 of the 26 letters among 90 possible rotor combinations (Figure 14). It was developed in Hut 8, a section in the GC&CS and required a crib as well as a portion of ciphertext with its matching plaintext, for which previous experience of earlier decrypts was advantageous.

Figure 14

A replica of Turing's bombe on display at Bletchley Park in Milton Keynes, England.



Rather than a very specific machine, Enigma was a far more general-purpose tool that could be used against both naval and army/air force messages, the first prototype named *Victory* and its first success taking place in 1940 (Wright, 2017). The crib was drawn up into a menu upon receiving the code, from which the Bombe then tested the assumption of every letter in the alphabet, and the simplest approach was to test each one in turn on separate Bombe runs. When the Bombe stopped, it gave both the position of the wheel wiring of the Enigma rotors as well as one

letter pair on the Enigma plugboard. The Bombes were administered 24 hours every day in Huts 11, 11A and 11B by female operators from the Women's Royal Naval Service (Wrens).

On his explanation of how Enigma worked, including the *Umkehrwalze* (reflector)—the main scrambler unit—and the *Ringstellung* (ring settings)—employed to change the position of the internal wiring relative to the rotor—, Patrick Mahon¹¹⁷ emphasised the simple affair this machine would have constituted had it not been for the *Stecker* rule.¹¹⁸ The following extract sums up the process of *stickering* (Mahon, 1945):

This is a substitution process affecting 20 of the 26 letters before and after the current travels through the wheels. Let us return to our original example and assume for the moment that A is steckered to F and N to T. In our example we pressed key A and entered the right hand wheel at a position we called A but if we now press A the current will be sidetracked before entering the wheel and will in fact enter at F and pursue a quite different course. If on the other hand we press F, the current will enter at A and proceed as before, coming out at N. N will not, however, light up on the lampboard, but rather T, because N has been steckered to T. This steckering process affects 20 letters, the remaining 6 are referred to as self-steckered and, when they are involved, the current proceeds directly to or from the wheels (p.4).

Until the end of WWII, Mahon participated in Hut 8 and wrote a typescript during his time at Hut 8 which dates back to June 1945. According to *Oxford Academic*, although the document remained secret until 1996, this copy was released then by the US government into the National Archives and Records Administration (NARA) in Washington, D.C., as well as another copy by the British government into the Public

117. Patrick Mahon (1921–1972) joined Hut 8 in October 1941 and became head of department from autumn of 1944 until the end of the war (Copeland et al., 2020).

118. The *stecker* rule refers to the *steckerverbindungen* in German—that is, the plugboard connections of the machine.

Record Office at Kew (Copeland, 2020).

While Hut 8 attacked Naval Enigma, Hut 6 partnered with Hut 3 and were responsible for the solution of German Army and Air Force Enigma machine ciphers. While these inventions, including the Enigma machine, the British Bombe and its successor models, have been the main focus of decryption during the wars, their development and usage would have been in vain had it not been for support of statistical methods that allowed both machines and humans to predict a code's behaviour. One of these methods, named Bayesian inference, was used to crack ciphers from the Axis alliance.¹¹⁹

Turing invented a sequential statistical scoring system based on Bayes' Theorem to "overcome the lack of bombs available for solving naval Enigma" (Erskine, 2008a: p. 200). Although it was a complex procedure, later known as "Banburismus", it essentially reduced the number of naval rotor orders by enabling Hut 8 to find which rotors were in each slot of the three-rotor naval Enigma (M3). The aim of Banburismus was "to obtain, with the help of the trigrams and fits between messages, alphabets 2 and 3, the middle and right hand wheel alphabets" (Mahon, 1945: p. 17). When the bigram tables changed, the captured keys advanced Hut 8's ability in August 1941 to break the Dolphin code, used by all U-boats, within two months (Erskine, 2008a).

Many of these techniques have been around additive codebooks, where the key determines the block ciphers (Stamp, 2006). At a higher level, even modern block ciphers use complex algorithms to generate ciphertext from plaintext. Frequency analysis was among the top 100 most popular methods to break these ciphers, a quite well-established approach that involved how many times a letter or set of letters was repeated so that the real message is induced by how frequent said letter appeared in the English language. Another common approach was putting yourself in the chair of your opponent, and thinking what a German operator would do in a given situation, and what they would do wrong. An apt analogy arises from considering the functioning of a clock, where the intuitive direction

119. The Axis alliance was formed by Germany, Italy and Japan during the WWII.

of its movement, commonly perceived as clockwise, assumes an inverse perspective when viewed from the perspective of the clock itself.

Failures in cipher security constituted a common event rather than an exception, sometimes because cryptography—the study and application of techniques to secure communication (Ferris, 2007)—, demanded a continuous need to review and update sophisticated procedures in order to break complicated systems. This never-ending development decreased the level of cryptography that the nation could endure at times in their own ciphers, while simultaneously spotting weaknesses in foreign cryptographic algorithms.

Interestingly enough, flaws in the German code were grasped because of human error, even though machines were supposed to be doing the tedious part of the job. By and large, operators were sometimes given the wrong instructions or made a mistake due to laziness. An example of setting the wrong procedure would be how the German team misunderstood randomness, so they would not allow the rotor to be in the same position as the day before. The problem relies on the fact that there were only 60 positions for the rotor to be, which would become a set of 59 choices the following day, and by the end of the month, only half of the positions would be available. This method turned out to be counterproductive, since the code became weaker due to the fewer possibilities for the rotor to be set in. Real probability would make it just as likely to be in the same position as it would be in any other, with no need to remove any rotors.

Operators were eventually given a set of combinations of three letters that would serve as a ground layer of security to set up the machine for the day, since otherwise the employees selected non-random combinations of letters and the code became more predictable. Sometimes because of unknown patterns within each person's mind and sometimes due to laziness, having an operator choose any of the so-called "random" ciphers was a huge problem, which was precisely how Mavis Batey¹²⁰ cracked a

120. Mavis Lilian Batey MBE (née Lever) (1921–2013) was one of the leading codebreakers at Bletchley Park (Copeland et al., 2020).

code.

While there was much traffic at times, codes were not needed every minute. Thus, encoding messages when there was no activity or strategy planned ahead was as important as sending the vital ones on time. Stopping sending messages altogether would have looked suspicious for the British team, knowing therefore to attack only when intercepting communication from the enemy. Codebreakers would get then many series of ciphers that did not mean anything and had no way of knowing until they sat and tried to work their way to decipher them. While this might have seemed like a waste of time, if the codebreaker realised that there was no real message behind the code, they could still learn how the key worked. Mavis Batey discovered that a cipher was a red herring because not all 24 letters of the alphabet were present, the letter “L” nowhere to be found. Therefore, she realised that the operator must have been pressing that letter the entire time, since it was impossible for any letter to be enciphered into itself. There was a string of different letters in which L was turned into every time the rotor changed, but the lack of L’s revealed the true nature of the code.

While it is estimated that over 75% of Bletchley Park’s workforce were female, evidence exists for fewer than half a dozen individuals holding high-achieving positions. This does not necessarily mean that they were the only ones to get to them, but that most were relegated to lower positions, leaving those senior roles at the top of the hierarchy for men. There might have been a few that there is no account of, but some of the names that resonate the most when talking about Bletchley Park are Jane Fawcett, Pamela Rosé (née Gibson), and Jean Valentine.¹²¹ Moreover, part of the team responsible for deciphering incoming codes included: Margaret Rock—who there is little information about—, Mavis Batey and Emily Anderson, an interwar codebreaker. They were the ones actually making the computer work, even though they had no previous

121. Jane Fawcett (née Hughes) (1921–2016) was recruited at 18 to Hut 6 as a civilian and worked for the Foreign Office decoding messages into German.

Pamela Rose (née Gibson) (1917–2021) was one of the Indexers in Hut 4.

Jean Rooke (née Valentine) (1924–2019) was one of the operators of the bombe in Hut 11.

access to the machine because of their initial lack of government security clearance (Blair, 2019). Being a vital component to the Allied success, women's work at this institution including computing and programming tasks became a way to integrate them in the workplace during wartime, but mirrored sweatshop-like conditions, working long hours in oppressive hot conditions.

As stated by his son Gethin Russell-Jones in Welsh codebreaker Mair Russell-Jones' biography, she was one of the few women who worked in Hut 6 after being approached by a man from the Foreign Office because of her language and puzzle-solving skills. She added that Bletchley Park always felt dark regardless of the season or time of the day, with the electric lights "generally on, shedding a kind of spooky light" (Russell-Jones & Russell-Jones, 2014, p. 13), which added to a heavy and intense atmosphere that was produced by the impossible codes that they had to solve. By 1943, the workforce had grown from a few dozen workers at the beginning of WWII to more than 5,000 and the institution required more the building of new blocks to accommodate them. There was a lack of information and feedback towards the employees, which reflects the extreme level of security and secretness that revolved Bletchley Park.

As stated earlier, there were employees in every stage of the process. Margaret Rock,¹²² who used to look at the series of messages that would come in, noticed that there was always a short message at the same time of the day, which made her think that it was likely a weather report (Twinn, 1993). Joan Clarke¹²³ was at another point of this chain and minded "the Baby". This small special-purpose machine was used to encipher a probable four-letter word at all positions of the machine according to the day's wheel-order and plugging (Clarke, 1993). While the naval keys changed at midnight, the wheel-order changed 10 times

122. Though little information is known, Margaret Rock (1903–1983) was one of the few mathematicians that held a high position within Bletchley Park and worked in the section run by Alfred Dilwyn "Dilly" Knox against German Intelligence Services traffic (GCHQ, 2020).

123. Joan Murray (née Clarke) (1917–1996) was a cryptanalyst and numismatist who was assigned to Hut 8. This department was in charge of breaking naval Enigma ciphers, which were among the most difficult to attack (Erskine, 2008b).

per month, which made it progressively easier to break. Clarke developed the second phase of the Yoxallismus method to recover the plugboard wirings of Enigma machines, but her peers did not give her credit for her work (Clarke, 1993).

German speaker Charlotte “Betty” Webb, MBE,¹²⁴ joined the British Auxiliary Territorial Service in 1941 because she was bilingual, where women outnumbered men three to one. According to the interview she granted to the *National Geographic*’s special edition “The Last Voices of World War II” in 2020, Webb stated that she “wanted to do something more for the war effort than bake sausage rolls”. She was not allowed to speak of her experiences as a member of Bletchley Park until 1975 due to the Official Secrets Act, the main legislative protection in the UK that made any unauthorised disclosure of information illegal.¹²⁵ Not even her parents knew what her job was, whom she told that she was in boring a secretarial position so that no one asked further questions. One of her first jobs was to register unintelligible messages in groups of five letters or figures, which would then be translated by linguists and classified as to where they should go to in order of importance. While she began by cataloguing these encrypted radio messages, she then moved “to a more creative role: paraphrasing priceless nuggets of intelligence gleaned by the code breakers so no one would suspect it had been obtained by broken codes” (Smith, 2020b) as the war progressed.

Contrary to popular belief, partially due to the persistence of the expression “cracking a code”, deciphering a message might seem to involve getting to know how a specific code works, but the reality is more complex than that. Very much like in problem-solving, where there is data that is already known to the solver, the codebreakers needed was an exhaustive key search, since they already knew how the code worked.

124. A Member of the Most Excellent Order of the British Empire (MBE) award is given to remarkable contributions to multiple fields such as arts and sciences as well as work with charitable and welfare organisations or public service outside civil service.

125. The Official Secrets Act 1911–1989 are all available at legislation.gov.uk, the official website managed by The National Archives where original (as enacted) and revised versions of legislation are published.

Key finding, however, was an arduous task since it changed frequently. Setting up your own machine in an identical position as Enigma would mean breaking the red key and being able to decipher all messages sent that day.¹²⁶ In practice, running through all the combinations was completely impossible. All the Sherlockian reasoning, distinguishing patterns from red herrings, deciding which transmissions to rule out and which ones to devote time to, which method to employ, was the real-life application of the development of problem-solving skills that the employees at Bletchley Park experienced.

126. The red key simply refers to another layer of encryption to Enigma settings.

6. Problem-Solving in Practice in a Higher Education Setting

This experiment was allowed to be conducted for students that took *Philosophical texts in the English language* (Code 33252), which is a compulsory course for all Philosophy undergraduates at the Universitat de València, during the academic year 2022–23. Taught at the Aulari I building at the Blasco Ibáñez campus, the space was big enough to easily accommodate over 80 people and was equipped with a computer, a projector and two blackboards. There were 67 people fully registered for the course, including four Erasmus students—three from Germany and one from Austria—and it was entirely taught in English.

Since this group had a weekly theoretical and practical lesson—from 9 to 11 am on Tuesdays and from 1 to 2 pm either on Monday or Tuesday, respectively—, the initial idea was to deliver a 2-hour introduction to the Victorian era and the various ways in which literary and cultural mysteries were introduced into society. The first part was intended to be more appealing to those who enjoyed mathematical-logical reasoning, whereas the second one explored how intuitive and creative enigmas could be. A B1 English level—which is the equivalent to what Spanish students are supposed to hold by the time they finish high school¹²⁷—would have been more than enough had the content been adjusted to said level. The potential presentation would then be followed by a seminar, which would have been taught at midday on both Monday and Tuesday because all students were distributed within one of those two groups. Nevertheless, after auditing said course several times, this idea did not seem doable.

Attending as a guest was pivotal to check whether students actually had an intermediate English level according to the Common European Framework of Reference for Languages (CEFR) or not: when interacting with them, however, many students visibly struggled with the language, many of them choosing to ask and answer questions in Spanish even if the lecturer employed English throughout. Because they all come from different backgrounds, learning (and mastering) English as a foreign language was not easy or even possible for many due to various circumstances. All their English journeys were different, and therefore

127. The LOMLOE Spanish educational law was modified in 2020 and is still in force at the time that this thesis has been written.

expecting full fluency was not a realistic goal. After careful consideration, the entire plan—including Power Point presentations and a draft of the schedule that were already done—was ruled out.

Going over literary theory seemed pointless if students were going to have a hard time understanding the content, which could have been adapted to a B1 CEFR level, but the vocabulary of which was too complex for beginners to grasp successfully. In searching for the best results possible, an interactive lesson was the one found to be the best, where they could work in groups based on a specific set of activities that allowed them to practise their English skills while being comfortable enough to ask the teacher individually or talk to their classmates should they have doubts. Moving from one activity to another could also make the class more dynamic and ensure that all of them were involved in the making.

6.1. Activities

A whole new Power Point (Appendix 10.3.) titled “Solving Mysteries”, was projected onto the screen as well as uploaded to the Virtual Classroom at the Universitat de València digital platform just in case some of them struggled to see the slides. With no more than two slides per activity, a short explanation of each exercise was provided in both English and Spanish, and the students—divided into groups of two to three members—had 10 minutes to complete each activity in a Word document or equivalent. Because some could take longer than others to get it done, they were given up until the end of the week to submit the assignment, which was named “Task 4” and was worth 5% towards their final grade.

24 students attended on Monday and 26 on Tuesday, plus an extra student who sent an email previously and asked to do it on her own since she was unable to go to class due to her full-time job. She was provided with an explanation via text and voice message and access to the Power Point, but not to the anonymous survey since she could not evaluate a class that she had not been at. These numbers make a total of 51 out of 67 students, which represents 76% of attendance. They were informed that

all answers needed to be at least a paragraph long as opposed to a couple of short sentences and that they were valid as long as they were justified properly. Once this brief explanation was over, the tasks were presented in the order specified on the Power Point and the following paragraphs within this section.

6.1.1. Crime scene

The crime scene was introduced as the first problem example. This decision was made because it was the activity that the vast majority of students could feel familiar with, either because of Conan Doyle's well-known novels or any other mystery crime drama TV show that they might have watched or heard of. The exercise was based on Sherlock Holmes' adaptation and the three pictures that were displayed within the slide had been taken from episode one of Series 1 of BBC's *Sherlock*, "A Study in Pink", which aired in 2010 for the first time. The students were told that Holmes does not use deduction to solve the cases that he is given, but rather employs induction or abduction. His reasoning is therefore not *deductively* correct, because he employs probability and considers his local and temporal context to make statements, a method that the students would have to apply to three premises (Appendix 10.3.):

- 1) The first picture shows a deceased woman facing down in a hotel room.
- 2) The second picture is a close-up of her left hand. She is wearing three rings on her ring finger. Next to her hand there are 5 letters that seem to have been carved on the ground, "R a c h e".
- 3) The third picture is a close-up of one of her rings. The inside is clean, while the outside is dirty.

This is all the information that the students were given. They were encouraged, however, to try and explain as much as they could: what happened, why or how. In the actual episode, Holmes got more clues—the dead woman's coat is wet, for instance—but given the time that they had to complete the task, three premises were already enough to work on.

6.1.2. Suspicious message

Once the first 10 minutes were over, all groups were asked to move on to the second task. Because of the importance that the agony column held during the Victorian era, this task felt the most appropriate to introduce 19th-century British culture to the students. They were given an explanation on how this section on the newspaper enabled secret communication between lovers and potential criminal activity, and how they needed to discover why the message that would be soon projected onto the screen was suspicious.

The message that the students had to analyse tried to be as close as possible to the Victorian style. The statement on a fictitious daily local newspaper was the following:

Message: «To James. Meet me this afternoon at the bakery at Macclesfield road in Holmes Chapel. Augustine is well again. Betty.»

Hint: If this is a daily local newspaper—and therefore it is printed out every day and only distributed within a town—how come Betty had to go and pay for the message instead of just going to James’s door and arrange a meeting in person? Why do they have to communicate via a newspaper? Who’s Augustine and what’s the relationship between all three?

Both the street name and Holmes Chapel exist in real life, the latter being a large village in the county of Cheshire, England. After reading the text out loud and made sure that all groups understood every word, an additional hint was given as an ice breaker.

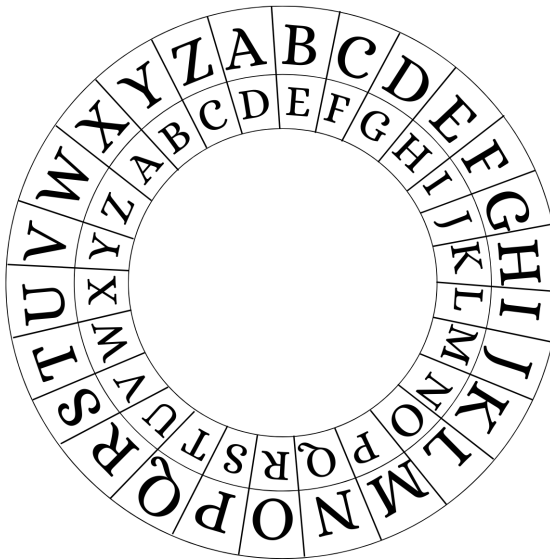
The clue seemed to help students, who began to talk about what this message might actually entail and provide a feasible story for task two. They were reminded that they should not forget Augustine—as many only focused on the sender and the recipient—and that a person had to physically go and pay for a piece of text to be considered for the newspaper.

6.1.3. Create your own cipher

For those that preferred a more rational way of thinking, a task that involved ciphers was included to test their mathematical-logic skills. This cipher was one of the easiest ones that could be found in hopes that some students might be reminded of their childhood and games between siblings or friends. Students were then asked to modify this wheel as much or as little as they wanted to create their own cipher. Given a brief introduction on how important this way of secret communication was during the war, the following example was shown on the screen (Figure 15).

Figure 15

Example of an easy cipher



Using substitution by moving 3 letters forward, the example code “MIDNIGHTS” would become “PLGQLJKWV”. When a student raised their hand and asked whether the cipher had to stick to letters, they were informed that they could easily go beyond the alphabet as long as an explanation was provided on how much they changed it and what method

they used. They could either write it down or even draw it should it find it easier to develop it visually.

6.1.4. Solve a riddle from Alice in Wonderland

From different types of logic to the lack thereof: this was the final task that they had to embark on. Although *Alice in Wonderland* was, along with Sherlock Holmes, the story that they might have heard of the most, nonsense literature made more sense as the last activity since they had been using logic throughout to solve different types of mysteries and now they had to come up with a logical explanation for a riddle that not even the author had an answer for instead. When a student raised their hand and rightfully said that Carroll had indeed provided a solution for riddle, it was explained that this reply had only happened *a posteriori* due to the overwhelming reaction that readers had towards the novel, and that, while it made sense, it had not been thought through when the novel was written.

Because the two elements within the riddle seemed fairly easy to understand, this was the last chosen question for them to solve, as stated by the Hatter in the first book of the series:

Why is a raven like a writing desk?

Some theories were given to the students for them to draw inspiration from, including Carroll's: that both the raven and writing desk produced notes, or that, while a raven eats worms, the writing desk is worm-eaten.

6.2. Responses

There were 20 groups of either 2 or 3 students—except for the one student that had to do it from home on her own—that handed in their assignments on time. These have been numbered from 1 to 20 in chronological order as they were received via email, the content of which are summed up with this section and discussed in the next one.

Tables 10-29

Responses from students

Group 1	
Crime scene	The dead woman was murdered and used her ring to tear the ground (hence it was dirty) and write the name of her killer.
Suspicious message	Either Betty is the murderer or she has been killed by James or Augustine and this message was published to make people believe that she is still alive.
Cipher	Each letter gets substituted by a number, starting with A = 1.
Riddle	Both a raven and a writing desk are associated with wisdom and thinking.

Group 2	
Crime scene	The word “Rache” stands for “revenge” in German, which might suggest that this was the motive and that they live in Germany. The wedding ring belongs to her husband, who killed her before leaving.
Suspicious message	James and Betty are having a secret affair and use nicknames to communicate via the newspaper. Augustine might be a metaphor for Betty’s private parts.
Cipher	Substitution by moving one letter backwards, i.e. S becomes R.
Riddle	A raven is trained to deliver messages while these are written down on a writing desk.

Group 3	
Crime scene	Her nails are only painted on one of her hands and the ring she carries is different from the one analysed.
Suspicious message	James and Betty are planning out Augustine's murder at the bakery that afternoon.
Cipher	Substitution by moving three letters forward.
Riddle	The raven perches on a branch, which is wood, the same material that a writing desk is made of.

Group 4	
Crime scene	The woman was meeting her husband to confess her real identity, "Rachel", but he felt betrayed and killed her, losing his ring in the process (hence it is clean).
Suspicious message	It must be a secret message since it makes no sense that they would communicate via newspaper to meet at a spot (the bakery) that all people must be familiar with.
Cipher	Substitution by numbers, starting with A = 1.
Riddle	Both a raven and a writing desk have feathers.

Group 5	
Crime scene	"Rache" is a message left by the murderer, potentially a serial killer, perhaps as a way of listing his victims.
Suspicious message	Betty and Augustine are married, but the former has been unfaithful for a year, reassuring James that her spouse was terminal. Augustine killed Betty after finding out about their affair and wants James to go to their meeting to take revenge on him too.
Cipher	Substitute each letter for its Greek alphabet equivalent.
Riddle	Both exist, tell stories, need trees and can be black.

Group 6	
Crime scene	The dead woman had started carving her murderer's name on the ground but was discovered halfway through, and s/he covered some of it with dirt so it might seem someone else's name.
Suspicious message	Either this is a warning for James, whose spouse Betty is meeting someone at the bakery, or is a criminal attempt to communicate with the family of the victim that they have kidnapped.
Cipher	Substitute each letter for its Greek alphabet equivalent.
Riddle	"As you can't see me at night, you wouldn't see me as a writing desk either."

Group 7	
Crime scene	The dead woman knew she was going to be killed by Rachel and started to carve her name with the ring, but finished with her nail polish when Rachel fled the scene.
Suspicious message	James and Betty are pseudonyms for two thieves and Augustine is a code for "money", as they stole it from Warrington bank, which is close to Holmes Chapel.
Cipher	Substitution by moving 6 letters forward, i.e. A = G.
Riddle	Both a raven and a writing desk are ways to deliver messages.

Group 8	
Crime scene	The dead woman has an affair, hence the ring being clean on the inside. She died from strangulation or overdose and Rachel is either the killer or a witness.
Suspicious message	James and Betty are having an affair and Augustine is their daughter, hence Betty asks him for money.
Cipher	Substitution by numbers, starting with A = 1.
Riddle	Both are associated with gloomy thoughts, dark symbology in literature and loneliness.

Group 9	
Crime scene	The dead woman was divorced from her ex-husband, who got married again. She wanted to have her wedding ring back and killed his new wife by accident, and he killed her back when he found out about it.
Suspicious message	Betty and James kidnapped someone and gave her a pseudonym, “Augustine”, as they want a reward.
Cipher	Substitution by numbers, starting with A = 1.
Riddle	Both scratch something (crops and a writer’s mind, respectively) and if you step on them, they both creak.

Group 10	
Crime scene	The ring was dirty because she started carving her murderer’s name on the floor but could not make it on time since she got killed.
Suspicious message	This message is addressed to Betty and has instructions for her to check the complete works of Saint Augustine for a secret message.
Cipher	Substitution by turning the alphabet around, e.g. A = Z. An extra number is added every two letters.
Riddle	Both are associated with witchcraft and spell-making, and they both turn into ashes if you set them on fire.

Group 11	
Crime scene	One of the dead woman’s neighbour, whose name starts with “Che”, killed her and wrote “Ra” at the beginning to that it would be confusing for the police.
Suspicious message	Augustine is the person that Betty and James want to murder, and Betty wants to arrange a meeting now that she feels better again.
Cipher	Substitution by numbers, starting with A = 1, e.g. 11 would be K, while a hyphen (1-1) indicates two As.
Riddle	Both a raven and a writing desk have feathers.

Group 12	
Crime scene	The first two letters within “Rache” are different from the other ones, which might suggest that the murderer (her husband) wrote them <i>a posteriori</i> .
Suspicious message	James is having an extramarital affair with someone, with whom he can only communicate via newspaper.
Cipher	Substitution by turning the alphabet around, e.g. A = Z.
Riddle	When a poet dies, the writing desk is the only thing that it is left, just like the raven when we die.

Group 13	
Crime scene	The ring does not belong to the dead woman since it is clean, so it is either a fake clue that the murderer left or his signature style. She was trying to write their name.
Suspicious message	The message is an alibi for the people that are committing a crime.
Cipher	Substitution by turning the alphabet around, e.g. A = Z.
Riddle	Both a raven and a writing desk have feathers and are associated with intelligence, literature and death.

Group 14	
Crime scene	The dead woman was trying to carve her murderer’s name with her ring, hence there is blood on it. She dies before managing to fully write it down.
Suspicious message	The message is a fake meeting to distract the police (the victim is already dead), while the criminals are preparing their next murder at some other place.
Cipher	Substitution by moving as many letters forward as the original position of said letter, e.g. B = D.
Riddle	A writing desk has feathers that allow your imagination to “fly”, while a raven flies because of them.

Group 15	
Crime scene	The ring is dirty due to her attempt to carve the reason why she was killed, “revenge” in German. She was attacked from behind; hence she is facing down.
Suspicious message	Betty kidnapped Augustine and is asking for James’s money if she wants her back.
Cipher	Substitution by numbers, starting with A = 1. An extra number is added at the end depending on whether the code is single-digit even, odd or prime or double-digit even, odd or prime.
Riddle	In some cosmologies, a raven represents wisdom, and the desk is a place to enhance our intellect.

Group 16	
Crime scene	The victim was dating a married man, hence the hotel with a bad reputation. The ring has been cleaned to remove any trace of DNA.
Suspicious message	Betty and James met 5 years ago before she left for Spain, and by the time she came back she had no clue on how to contact him so she decided to write on the newspaper in hopes that he would read it.
Cipher	Substitution by turning the alphabet around, e.g. A = Z.
Riddle	Both a raven and a writing desk have feathers and legs.

Group 17	
Crime scene	The ring could not have been used to carve something as it is not a sharp object and is dirty, which does not match the woman’s smart look. It is a misleading clue.
Suspicious message	“Augustine” is a code for the bomb that two criminals are planning to drop at the church (next to the bakery).
Cipher	Substitution by adding an extra inner circle.
Riddle	Both are associated with knowledge, loneliness and death and they are often romanticised.

Group 18	
Crime scene	The dead woman was having an affair, which her husband discovered: when he killed her, she tried to carve the word “revenge” in German for the police.
Suspicious message	Betty and James have an affair and have poisoned Betty’s husband to run away together with his fortune, but he seems to unexpectedly get well again.
Cipher	Substitution by turning the alphabet around, e.g. A = Z.
Riddle	Both have feathers and while a raven flies, the writing desk allows someone’s imagination to fly.

Group 19	
Crime scene	The inside of the ring is clean because the dead woman took it off, presumably because she was cheating on her husband, who killed her upon said discovery, hence the word “revenge” in German.
Suspicious message	“Augustine” is a code for the drug that Betty (who gives it to local sellers) and James (who sells it to clients) are trafficking with in Holmes Chapel.
Cipher	Substitution by the alphabet that the group created.
Riddle	According to Democritus, one could say that both consist of atoms and emptiness.

Group 20	
Crime scene	The ring belonged to her fiancée’s grandmother, who killed the dead woman upon waking up from a coma and finding out that her grandson had given it to her.
Suspicious message	Betty and James are plotting to commit a crime, but need to meet secretly as they are under suspicion.
Cipher	Substitution by numbers, starting with A = 12.
Riddle	The raven perches on a branch, which is wood, the same material that a writing desk is made of.

6.3. Anonymous Survey

50 people handed in the anonymous survey at the end of the lesson, which is available at the Appendix 10.6.¹²⁸ This questionnaire was divided into four categories: organisation, content, the relationship between students and the teacher, and their interest towards the activities. While they were all conventional ways of evaluating a class, the third category was thought to be decisive since it focused on the students' wellbeing and their honest opinion on what they learnt, which is crucial to ensure a comfortable learning atmosphere and inclusive quality education as stated by the SDGs. These questions were preceded by age and gender for statistical purposes.

After going over all the surveys, all data was gathered except for two of them. These evaluations were invalidated due to different issues, the first one being that when a student suggested readings that were completely unrelated to the activities but connected to previous lessons, it became evident that he mistakenly believed he was evaluating the entire course instead; the second case was someone who did not notice that there were two sides within the same sheet to complete, so many questions were left unanswered. Although there were two extra students who forgot to answer one question each (the first and last question within the organisation category), these are isolated cases and do not affect their performance: they answered more than 90% of the questionnaire, and consequently do count towards the results. There was one additional student that decided to participate and provided her own answers to the activities but could not make it to the class, so she could not fill in the survey. 48 students were considered to having filled in the questionnaire successfully and only their responses are therefore taken into consideration.

Out of these, 27 were 19 years old at the time that they attended the lesson (56.3%); 9 were 20 (18.8%); 6 were 21 (12.5%) and there was one single student that was 18 (2.1%), 22 (2.1%), 23 (2.1%), 24 (2.1%), 27 (2.1%) and 28 (2.1%), respectively. When asked about their gender,

128. Although APA 7 states that numbers from zero to nine should be written as words, all numbers related to scores are written as numerals in this chapter for clarity purposes.

22 students stated that they identified themselves as female (45,8%), 19 as male (39.6%), 5 as non-binary (10.4%) and 2 people decided not to answer (NA, 4.2%). The rest of the statements except for the open question at the end had to be evaluated from 1 to 5 according to the Likert scale¹²⁹ (1—strongly disagree, 2—disagree, 3—neutral, 4—agree, 5—strongly agree). All results are rounded up from .51 onwards, hence some answers seem to reach a total of either 99% or 101%.

The first category was “Organisation”, the statements of which were the following:

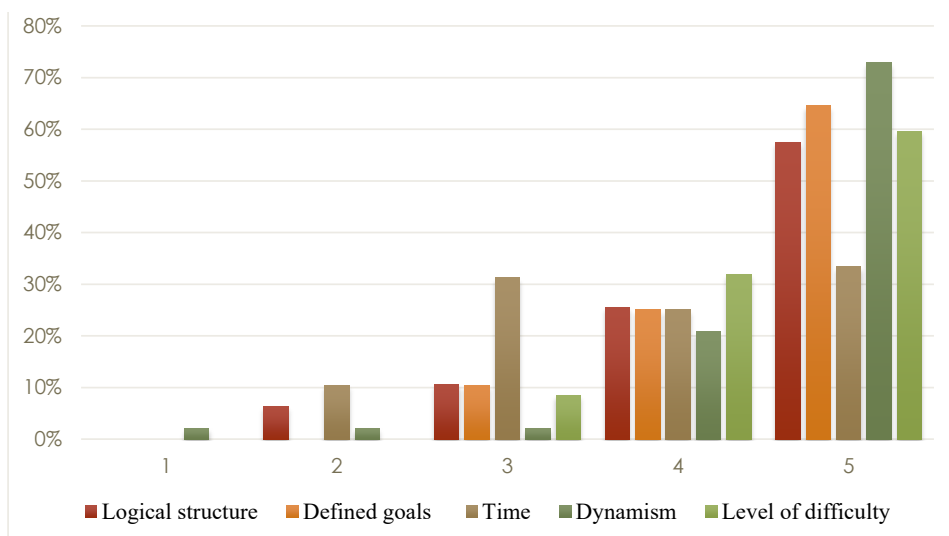
- The activities followed a logical structure.
- The goals were defined clearly.
- The right amount of time was spent on each activity.
- The class was dynamic.
- The level of difficulty was adequate.

As shown on Figure 16 (next page), there is an average of more than 4 except for “Time”, which 31% of students chose neutral for. The results, however, were positive overall. Less than 10% of students responded negatively (disagree or strongly disagree) to any question, while four of them achieved a score of 5 (completely agree) in over 50% of the responses. When asked if the lesson had been dynamic, an average of 4.6 out of 5 was registered, with 73% of the class choosing the maximum score and only 6% selecting anything lower than 4; the level of difficulty of the tasks as well as how defined the goals were achieved a similar average of 4.51 and 4.54, respectively; when it comes to logical structure, the final result was an average of 4.34 as 83% of students selected 4 or higher while 17% chose either 2 or 3.

129. The Likert scale measures the collective responses to a set of items.

Figure 16

Organisation



The second category, “Contents”, focused on the ideas and topics that had been presented as well as their thoughts on the future application of the skills that they had employed within the hour. The statements were the following:

- I learnt about different ways of solving mysteries.
- I found the content interesting.
- I feel like I learnt something new.
- I think the activities helped to develop my problem-solving skills.
- I think the activities helped to develop my critical thinking skills.
- I think that what I learnt might be useful in the future.

Only two graphics—which correspond to the fourth (Figure 17) and fifth statement (Figure 18), respectively—are included as they are the most important part of this specific category.

Figure 17

Problem-solving graphic

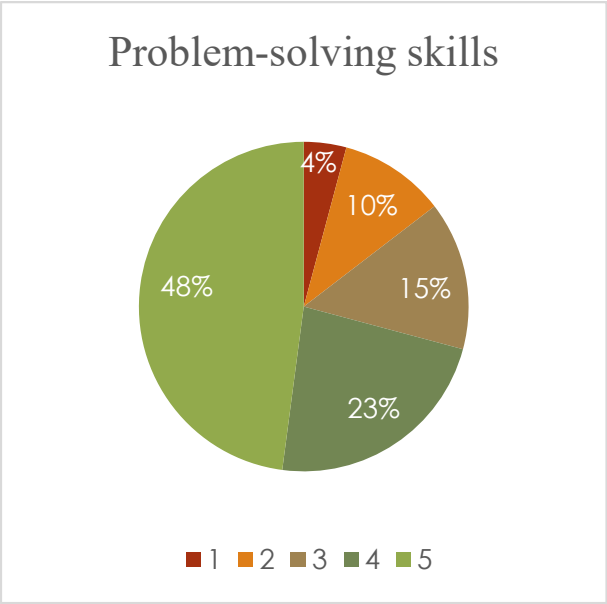
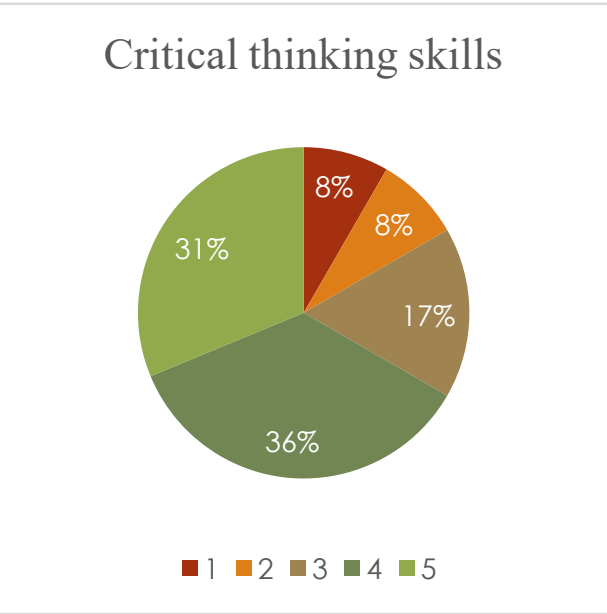


Figure 18

Critical thinking graphic



Over 70% agreed when asked whether they felt that these activities could help them to work on their problem-solving skills, almost half of them (48%) choosing the highest score (5). 15% felt neutral towards it, while 14% disagreed and gave a 1 or 2 score. This number slightly increased when asked about critical thinking, where 16% responded negatively and 17% chose a neutral answer. Still, the average was positive, with 67% of the students agreeing.

The remaining four questions within the same section generally obtained positive results as well. While 69% of students stated that they felt like they dealt with different ways of solving mysteries, 4% disagreed and 27% remained neutral. The vast majority did find them appealing, achieving an average of 4.52 as 92% chose either 4 or 5. 29% chose a neutral option when asked if they learnt something new, 58% answered positively and 12% negatively. Lastly, 23% did not find the content useful (either 1 or 2), 23% were not sure and 54% thought that they could apply the knowledge that they acquired in the future.

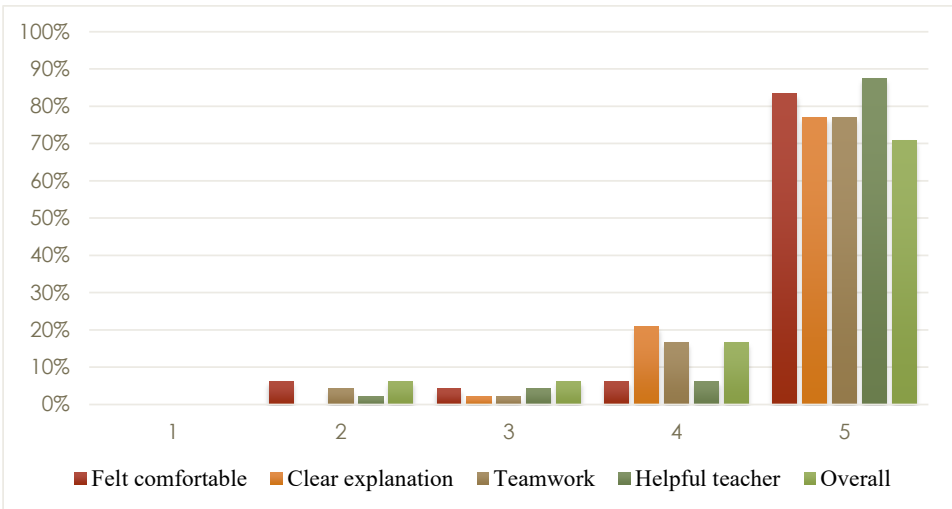
The third category was “The students and teacher”, which was intended to reflect the class atmosphere as well as the relationship between both parts. As stated before, this was extremely important for the study along with the development of problem-solving and critical thinking skills, because a good classroom environment is critical for the exchange of knowledge and student learning comfort (Lage et al., 2010; Davies et al, 2013; Closs et al., 2022). This time, these were the sentences that they had to agree or disagree with:

- I felt comfortable during the class.
- The teacher explained the activities clearly.
- The activities encouraged teamwork.
- The teacher was approachable and willing to help.
- Overall, I enjoyed the class.

As shown on Figure 19, over 80% of students strongly agree on feeling comfortable in the class, and 93% chose either 4 or 5 regarding having clear instructions to carry out the activities. When it comes to encouraging teamwork, 4% of students did not think that it was included enough, while 1 student (2%) remained neutral and 94% responded positively. 94% agreed or strongly agreed that the teacher was approachable and helpful, while 2 students (4%) were neutral towards said statement and 1 (2%) disagreed. Generally speaking, over 85% said that they enjoyed the class, 3 students felt neutral (6%) and 3 disagreed (6%), respectively. It is worth noting that “the students/teacher” part attained the highest scores, all the statements within this category achieving a minimum average of 4.52.

Figure 19

The students and the teacher

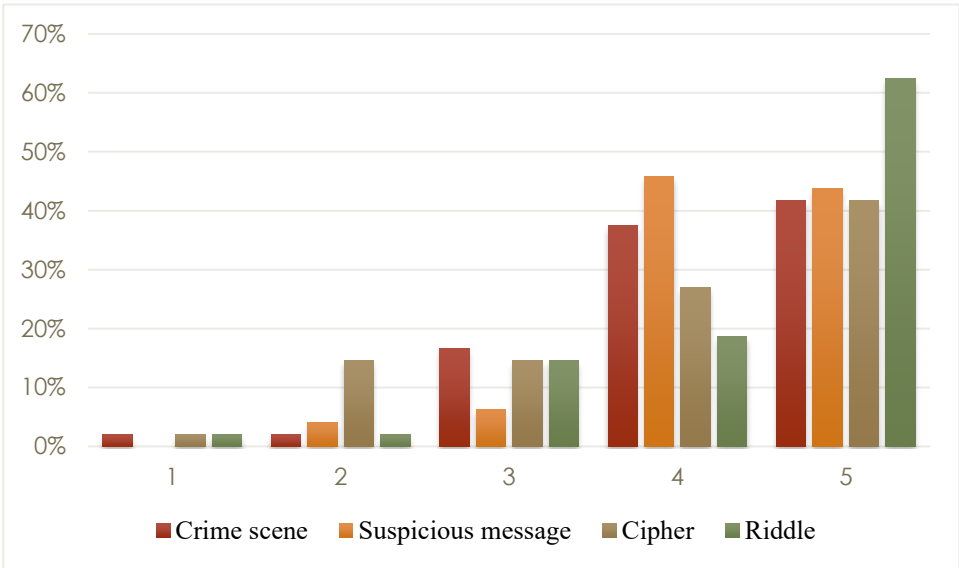


The fourth part of the questionnaire focused on the individual evaluation of each activity in the order that they had been presented, as shown on Figure 20. The crime scene received one 1 and one 2 vote, respectively, but had an overall high score of 60% of people who enjoyed the activity. The second task, speculating about a suspicious message on the

newspaper, got a higher approval ratings by achieving 90% of positive responses (4.33 on average). While still having a good reception, creating your own cipher was deemed as the least enjoyable activity as 1 student did not find it interesting at all (2%), 7 students did not have much interest (15%), 7 remained neutral (15%), 13 (27%) found it engaging and 20 (42%) gave the maximum score. On the opposite side of the spectrum, solving the riddle from *Alice in Wonderland* attained the most positive votes, 63% of them being 5 (extremely interesting) and getting an average of 4.38.

Figure 20

Interest in activities



Not every student filled in the open question since it was optional, but almost half of the students (48%) left a comment on what they liked (70%), suggestions about what could be improved (22%) or a mixed review (9%). The two students that gave the latter wrote about how the tasks were fun but there was not enough time to complete them and how the teacher’s attitude was positive yet did not feel like the activities were the best way to improve critical thinking. Those who gave constructive

criticism stated that they would have liked to know a set answer for each activity and one student suggested that one or two more hints for the crime scene would have proved to be useful. Two students could not really see many associations between these exercises and Philosophy, and would have liked for this relationship to be clearer.

Some positive comments were brief and just stated that they enjoyed the class, while others were more specific and mentioned the stimulation of imagination, a continuity between activities or how fun and dynamic they found it. Moreover, some emphasised how non-conventional, different or interesting the tasks were and how they allowed them to apply knowledge in new ways. Three respondents stressed one of the exercises as their favourite: one expressed their love for Sherlock Holmes and two stated how the riddle from *Alice in Wonderland* was interesting, especially because the solutions that they could provide were not as limited as in the previous tasks and enabled more arbitrary associations.

7. Discussion

7.1. General Results

The outcome of this research provides insight into the relationship between British literature—as something you can *read*, not just as fiction—and the potential development of problem-solving skills for a Global Citizenship as encouraged by the SDGs of the United Nations (Domene Benito & Haba Osca, 2022). The human need to unravel mysteries has been present since the beginning of time, so it is only natural to research its benefits, and the scope that they can reach. Throughout this thesis, the importance of building a strong set of transferable skills for current global issues is shown from the historical presence of problem-solving in literature.

In line with the hypothesis, the connection between the two seems evident: far from being a practice that stayed in the Victorian era, problem-solving appears both in serious matters and in more light-hearted contexts such as the entertaining industry—there are contemporary artists that this tradition was passed on to. This means that not only was developing this skill pivotal in the past, but that it still attracts the audience's attention nowadays (Egenfeldt-Nielsen, 2013; Dietrich et al., 2021). Positioned today as one of the most demanded within the workplace, it can cover a wide range of situations from changing route to go to the post office when there is a congestion to falling in love until it hurts, bleeds, or fades in time. In accordance with the theoretical framework, these scenarios also encompass significant global crises, which manifest alarming statistics regarding poverty rates, the accessibility of secure infrastructures, and the equitable distribution of opportunities.

These results are relevant because the holistic core of problem-solving goes beyond a specific (complex) situation to designing a working context that enables the solver to manage any sort of complex situation (Espinosa & Walker, 2011). In other words, they might be able to succeed in situations that are not identical from the ones they have experienced before from an open, resourceful perspective. It is precisely through this transferability and adaptability that the SDGs come into play, since the practice of literary enigmas allow the activity in certain neurological areas that will act as a memory sponge. This might pave the way for an easier approach next time that a similar situation is introduced.

Getting presented with a situation that the solver is unsure as to how to deal with draws on neuroplasticity, and the ability to recall past experiences that might help the new one (Raskin, 2011; De Oliveira, 2020). If there is no base to learn upon, or a completely lack of resources from the solver's side, the problem will remain unsolved: therefore, the more experiences one has, the more likely it is to gather information that could potentially be transferred later on (Chen et al., 2023; Molnár & Greiff, 2023). Though predicting which data will be more convenient in the future is rare, foreseeing a specific application is not necessary for the learning process to be advantageous. On the contrary, it might provide the solver with a wider variety of tools to manage personal and professional circumstances (Robertson, 2016).

Encouraging critical thinking, decision-making, tolerance, resourcefulness, creativity, and openness towards others' perspectives are just some of the factors that involve problem-solving, a complex ability that can become a game-changer if played good and right (Sen, 2011; Birgili, 2015; UNESCO, 2023b). Once again, this could be developed through multiple disciplines (Gardiner, 2020), such as working out what danger a bacterium poses from looking at the microscope and crisscrossing data from previous free-living organisms or securing international peace by establishing relationships that are fair to all parties in politics. As previously stated, however, one of the most tangible applications is acquiring a Global Citizenship mindset, acting with a sense of responsibility towards addressing global challenges and promoting universal values such as sustainability and peace. Thus, this study does not limit the possibilities of problem-solving, but rather enhances how it could be accomplished from an interdisciplinary perspective and acknowledges the power of every field to help in this mission.

7.2. Problem-Solving: Case Studies

Culturally speaking, the Victorian era and early 20th century might have had the most obvious connection to enigmas, the data in this thesis contributing to a clearer understanding of that specific period of time

within a wider literary context. The ever-changing social adjustment to revolutionary technologies as well as the acceptance and curiosity towards spiritual awakenings coexisted in the same space (Noakes, 2004; Andrick, 2023). This situation enhanced the liking for tracing clues leading to the solution of a greater mystery.

The Sherlockian case shows how thinking about all the possibilities before acting upon a situation is a key step when solving a case. In real life, this is similar to what a computer algorithm does, but at a human level: examining all the pathways that there might be to approach a problem and finding the best alternative by reducing the probabilities of an event happening (Schnotz et al., 2010). Though every perspective is subjective to some extent—and any solver will be biased by many factors such as previous experiences, their environment and personality—taking a step back and thinking rationally about a situation (e.g. picking up on details from a situation and relating them to stored information) might help to process the new one. If the initial attempt fails, it might be necessary to consider other explanations that seemed unlikely at first. As stated earlier in the theoretical framework, some solutions for the SDGs have been effective, but there are some others that fail to meet the goals by the UN (Leal Filho et al., 2020; Takyi et al., 2021; Fulzele et al., 2022; Perkins et al., 2022). Therefore, these attempts should be re-evaluated by considering context—such as the variety of resources within countries, where the same measure cannot be applied and should respond to their own needs and concerns in a fairer way (Ferguson et al., 2018).

Lewis Carroll serves as a role model for his engagement in problem-solving. Without getting too obsessed, his case can be applied to real life due to his innovative take on knowledge, determined to work around something that he could not solve rather than succumbing to defeat (Gardner, 1996; Moktefi, 2018). If he felt like he had mental resources, he would try to find routes to shed light to an unsolved mystery—sometimes succeeding and sometimes failing, but everything contributed to his process of life-long learning. Raising awareness about the SDGs in the classroom from a young age and studying what the current solutions fail to provide by analysing and practising similar problems

in the past might prevent humanity from making the same mistakes in the following decades (Haba Osca, 2023). This goal, however, can only be accomplished through hard-work and having realistic expectations of what can be done now.

Ada Lovelace represents the bridge between theory and real-life application of data, adamant that all the years that she had spent learning had to become something material, practical. She saw different fields of knowledge as interconnected and encouraged readers to go beyond the boundaries to discover patterns and establish relationships between them (Strawn, 2023). Her attitude embodies the courage that is needed to think outside of the box, evidenced by her attempt to draft a prototype of the first algorithm by adapting concepts from the past in hopes that they might change the future. Acknowledging the importance of trial and error, the learning process is seen as somewhat helpful in every step for the mathematician, who did not daunt her spirit when facing failure (Lovelace, 1843). Had she not experienced those mistakes and gone beyond the translation that she was in charge of to write her own production, a major contribution to computer science would have been lost today (Charman-Anderson, 2020). Though finding the balance between the thirst for innovation and a down-to-earth mindset is a fragile subject, this state of grace allows the rational analysis of an issue while leaving room for ideas to grow.

From desperate times to needing immediate action, the work at Bletchley Park resembles the urgency to develop problem-solving for the SDGs the most. The lives of many were at risk and often depended on the ability of the codebreakers to anticipate every move and act to prevent a catastrophe from happening before it was too late (Millward, 1993; Smith, 2021). The techniques that they used were plenty but included putting oneself in the enemy's shoes to see the same situation from another perspective and having a strong decision-making ability that enabled them to prioritise some tasks over others (Kenyon, 2019). While the circumstances are entirely different—and hopefully words such as “enemy” are avoided in the journey to a better planet—their cooperation was essential to act together against the same threat. By putting a fair life for everyone first

and working as a team to achieve common goals, applying problem-solving becomes an easier activity that can help to ensure living life peacefully.

7.3. Problem-Solving in Practice in a Higher Education Setting

The lesson was intended to provide an example of how some of the case studies could be applied to a university class, but it is by no means a significant representation of the influence that they could entail. The generalisability of the results is therefore limited by the number of students that participated, and only serves as a sample of how the implementation of dynamic material could impact the development of problem-solving skills. Due to the lack of data on the neurological effect that doing these activities on a regular basis could have, the results cannot confirm how beneficial they could be in the long-term. Nevertheless, the hypothesis is that, given the historical path and natural interest for problem-solving as well as the proven effects on the human brain that previous studies showed, they could likely become a tool in fostering this ability.

The results suggest that the students enjoyed a lively lesson that allowed them to work in groups while coming up with their own ideas. While education is not the main subject of this thesis, and life is a long-learning experience, a significant part of acquisition of knowledge starts from the school and university years, and this experiment was therefore thought to be appropriate. Intended to be an indicator of potential, it hints at the possibility of introducing this skill from a practical perspective rather than a purely theoretical one, and making sure that the students are prepared to face and overcome a hectic environment that will include the dangers of not meeting the SDGs on time (Haba Osca, 2023).

8. Conclusion and Future Perspectives

The PhD thesis concluded that the enhancement of problem-solving skills is essential to manage daily situations, but also serves as a tool to approach major issues such as having a Global Citizenship mindset to contribute positively to the planet as a whole. Future studies should take into account sustainability when conducting research, as it is a current real-life application that affects everyone's lives. While seemingly unrelated at first, this study shows how bridging fields of knowledge such as literature and Global Citizenship is an interdisciplinary way of understanding learning. In reality, it is imperative to establish connections between situations and recollect a continuous flow of information from past experiences, rather than rigidly adhering to a single discipline.

Just this doctoral dissertation cannot cover the needs of SDGs, and there is a growing body of articles that attempt to contribute to their study, but there is still a lack of resources and awareness of how important these skills are. A neurological study on how the brain reacts when being exposed to different types of activities that require problem-solving would have been a great complementary resource, but the lack of financial aid did not allow to do so. Further research is needed to establish all the relationships between the activation of different areas within the brain when performing these activities.

Avenues for future research include the incorporation of other disciplines to the race towards a Global Citizenship and sustainability, bringing interdisciplinarity to the table and therefore a more realistic approach to overcoming obstacles in the way. Having a control group that performs practical problem-solving activities before having a discussion about SDGs might make them more successful in their approach than the brainstorming of a group that has not practised before, but this needs to be tested more times for the hypothesis to be confirmed. This thesis, however, goes beyond abstract terminology to place the acquisition of these skills through literary enigmas as one of the formulas for a Global Citizenship—arguably one of the most tangible applications that they could have at this period of time.

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10. Appendix

10.1. Tesi en català (menció internacional)

As part of the international doctorate mention, a set of sections are included in Catalan, since that is one of the official languages within the Valencian Community, Spain, where the Universitat de València is located.

10.1.1. *Justificació*

La resplendor incandescent del coneixement ha persistit al llarg del temps, donant maldecaps a la humanitat quan intenta captar la resposta als misteris més grans de la vida, i esdevenint una tasca frustrant però emocionant quan romanen sense resoldre. Comprendre com funciona la gravetat o desxifrar el primer sistema de numeració basat en múltiples de deu pels egipcis van ser avanços que van canviar la vida per sempre. Encara hi ha preguntes, però, que persegueixen la ment de la gent quan es mira el sostre a la nit, com ara si hi podria haver vida fora de la Terra, què va causar l'incendi a La Gran Biblioteca d'Alexandria, o com frenar l'avanç de la malaltia d'Alzheimer. L'enigma pel qual es pot perdre el son no ha de ser un problema important, sinó que pot aparèixer diàriament, des del disseny d'una estratègia de màrqueting fins a un desamor inesperat, on l'anhel latent de veure'l tornar s'esvaeix en el dia.

Periòdicament, els humans es troben amb situacions que no són fàcils de resoldre, i desenvolupar les habilitats per gestionar-les de manera eficaç és tan important com adaptar-les a problemes lleugerament diferents que poden ocórrer a la vida real (Fischer et al., 2012; Prastika et al., 2020). La resolució de problemes engloba un conjunt complex d'habilitats, com ara el pensament crític i lateral o la presa de decisions, que s'activen en identificar dades i prioritzar i seleccionar alternatives (Schnotz et al., 2010; Birgili, 2015). Aquest procés requereix un deslligat o afluirament que depèn de la capacitat d'entendre principis, teories o models a través d'experiències prèvies (Kim i Grunig, 2011; Bassok i Novick, 2012). Tot i que el seu estudi normalment s'ha enganxat només a les matemàtiques o s'ha relacionat exclusivament amb el lloc de treball, no gaire investigació s'ha centrat en que siguin un conjunt d'habilitats que es puguin aplicar

a qualsevol lloc, i molt menys tenint en compte la Ciutadania Global per als Objectius de Desenvolupament Sostenible (ODS), que encara tenen bretxes significatives de coneixement (Zimm et al., 2018; Allen et al., 2019; Kathambi, 2023).

A causa de l'estat d'emergència en què es troba el món en aquests moments, ajudar a desenvolupar aquestes habilitats per diferents mitjans és una crida urgent per a tothom (Nacions Unides, 2015; Perkins et al., 2022; Fulzele et al, 2022). Per tant, això no vol dir necessàriament que aquestes habilitats només es puguin construir a través d'enigmes literaris tal com s'analitza en aquesta tesi, sinó que és una de les maneres de fer-ho; a més, els enigmes es classifiquen com a "literaris", però són no exclusivament de ficció. Així, en el marc teòric d'aquesta tesi es divideix en una visió general de la resolució de problemes en la literatura britànica com enigmes, xifres o endevinalles i una evolució del mateix concepte. A aquesta secció segueix la metodologia i quatre estudis de cas que mostren diverses maneres d'aplicar aquesta habilitat: el mètode de raonament de Sherlock Holmes, la pràctica constant de Lewis Carroll, l'intent d'Ada Lovelace d'esborrar el primer algorisme de la història i el trencament de codis a Bletchley Park durant la Segona Guerra Mundial.

Si bé també s'haurien pogut estudiar altres períodes, es pensava que l'època victoriana i postvictoriana proporcionava grans exemples de com es desenvolupaven els passos a l'hora de resoldre un problema a causa del màxim interès pels enigmes, els trencaclosques i la comunicació secreta que van experimentar, una època on disciplines tan diferents com la ciència i l'espiritisme van conviure (Pavlik & Regret Iyer, 2023). Això fa que aquesta època sigui encara més apropiada per a l'estudi de la resolució de problemes, ja que la vida real requereix enfocaments holístics per part de la persona resolutora a l'hora de superar una situació desconeguda (Meyer i Scholl, 2009; Robertson, 2016; Awasthi i Mohanty, 2021; Guo et al. , 2023).

Escollir la University of Surrey al Regne Unit (Regne Unit) per a l'estada de recerca a l'estranger no va ser arbitrari. Lewis Carroll va passar una estona a Guildford, la ciutat on es troba aquesta institució superior, i tant el Magdalen College com la biblioteca Bodleian d'Oxford i Bletchley

Park en Milton Keynes es trobava a prop perquè es pogués dur a terme investigacions en persona per als estudis de cas. Fins i tot es pot veure una estàtua d'*Alicia a Través del Mirall* (1871) als voltants del castell de Guildford, i una estàtua d'Alan Turing es troba davant de l'edifici Austin Pierce al campus. A més, la supervisora i directora de l'Escola de Literatura i Llengües en el moment d'aquesta tesi, la Dra. Patricia Pulham, era una experta en l'època victoriana, la qual cosa va fer que la seua orientació fos convenient per al projecte. Finalment, l'excel·lent posició acadèmica que ocupa la Universitat dins del país i els seus amplis recursos podrien elevar el contingut d'aquesta tesi.

1.1. Objectius

- Fer veure com la resolució de problemes ha estat present al llarg del temps, ja siga en forma de xifrats, trencaclosques, endevinalles o qualsevol altre tipus d'enigma
- Comprendre la necessitat d'adquirir habilitats de resolució de problemes, tant amb finalitats externes com pels seus efectes neurològics positius
- Considerar els estudis de cas com a exemples del paper fonamental dels enigmes literaris a l'època victoriana i postvictoriana en un context literari més ampli
- Connectar tant la teoria com la pràctica perquè els coneixements previs es puguin aplicar a situacions futures de la vida real
- Sensibilitzar sobre una Ciutadania Global per als 17 Objectius de Desenvolupament Sostenible (ODS) fomentant el desenvolupament d'aquestes habilitats com a eina potencial per mitigar els efectes del canvi climàtic

1.2. Hipòtesi

La resolució de problemes s'ha estudiat anteriorment, però rarament des d'un enfocament literari, i molt menys tenint en compte la Ciutadania Global com a objectiu final. Aquesta tesi pretén abordar aquesta bretxa amb l'esperança que pugui conscienciar sobre la necessitat de disposar

d'eines per a una crisi mundial. Per tant, la hipòtesi és que la potenciació de la resolució de problemes ajuda a gestionar situacions personals i professionals però també pot servir per resoldre grans conflictes, la qual cosa és fonamental per als ODS. Tot i que això es podria provar i verificar a través de molts mitjans, el focus es centra en l'estudi interdisciplinari de la relació entre la literatura britànica i la resolució de problemes, i com això es pot aplicar a situacions de la vida real.

10.1.2. Metodologia

Enfocament general i estructura de la tesi

Tot i que la tesi és de caràcter interdisciplinari, combinant literatura britànica i resolució de problemes, segueix l'estructura tradicional dels doctorats en humanitats a Espanya i al Regne Unit. La tesi comença amb la justificació de l'estudi, on s'estableixen els objectius com la hipòtesi i se'n menciona la rellevància; en segon lloc, s'inclou un marc teòric exhaustiu per donar context al lector, seguit de la metodologia que s'ha emprat; en tercer lloc, quatre estudis de cas il·lustren maneres de millorar la resolució de problemes conjuntament amb una experiència a l'aula com una aplicació real d'aquestes habilitats; finalment, es discuteix el que poden reflectir els resultats i una conclusió que implica possibles perspectives de futur sobre el tema.

Pel que fa al marc teòric, hi han dos cossos principals d'investigació: la història de la resolució de problemes a la literatura britànica i les habilitats de resolució de problemes per a una Ciutadania Global, respectivament. S'ha considerat que dona informació suficient sobre com aquestes habilitats sempre han estat presents, i pot esdevenir un canvi de joc per als problemes globals actuals. En una primera part, l'evolució dels enigmes des de l'època medieval fins a l'època contemporània ofereix una guia completa de com han evolucionat, però l'esperit dels quals es manté intacte; en la segona, es desenvolupa una introducció sobre el raonament i el panorama canviant de la resolució de problemes. Això permet al lector veure aquesta habilitat més enllà de termes abstractes i tenir una visió general dels seus efectes positius sobre el cervell i les

aplicacions de la vida real.

Per a aquesta secció s'han utilitzat recursos tant físics (llibres, manuscrits) com digitals (revistes científiques, mitjans de comunicació). Les biblioteques, l'accés a les quals va ser concedit per la filiació a una universitat espanyola i una britànica al llarg del doctorat, van ser les següents: les biblioteques Joan Reglà (humanitats), Eduard Boscà (ciències) i Pelegrí Casanova (ciències de la salut) de la Universitat de València (Espanya), la biblioteca principal i centre d'aprenentatge de la University of Surrey (Regne Unit), la British Library (Regne Unit), i el Magdalen College i la Bodleian Library de la Universitat d'Oxford (Regne Unit).

La Ciutadania Global com a aplicació definitiva de la resolució de problemes

Tot i que la resolució de problemes pot tenir moltes aplicacions, la Ciutadania Global és l'objectiu final d'aquesta tesi, ja que tenir un sentit de responsabilitat envers el benestar del món pot ajudar a pal·liar problemes de la vida real com el canvi climàtic o la manca d'infraestructures en algunes zones del món. S'ha contactat amb alguns experts en els ODS per confirmar la importància de desenvolupar aquest conjunt d'habilitats i donar solucions a situacions que amenacen la vida, un d'ells és el doctor Arman Sarvarian, lector de Dret Internacional Públic a la University of Surrey, el treball del qual amb els òrgans de l'ONU el va portar a afirmar que “la resolució de problemes és sens dubte una habilitat que no només seria útil sinó que diria indispensable a l'ONU, donada la complexitat i dificultat típica de buscar solucions”.¹³¹ La University of Surrey també va comptar amb un Institut de Sostenibilitat que va insistir en la importància de dibuixar projectes ecològics i la inclusió de col·lectius per als quals el cost de la vida i les desigualtats en salut tenien un impacte desproporcionat, el progrés dels darrers anys disponible en el seu últim *L'Informe sobre els Objectius de Desenvolupament Sostenible 2023: Edició Especial*.

131. Aquesta conversa es mantingué per email i no pot ser inclosa a l'apèndix per motius de privacitat de dades.

Criteris de selecció dels casos pràctics

Els estudis de cas es van establir per representar alguns dels molts enfocaments que les persones resoltores podrien adoptar o descartar quan s'enfronten a un problema. En el primer cas d'estudi, Sherlock Holmes com a base de l'ús de la inferència és un exemple literari conegut que podria semblar familiar per al lector i fer que la tesi siga interessant per a un públic més ampli. El procés de pensament del detectiu és especialment rellevant per a aquesta tesi, ja que considera totes les possibilitats abans d'arribar a una conclusió i no es rendeix fins que es confirma una de les seues hipòtesis. L'experiència de la Dra. Patricia Pulham, supervisora i cap de departament de la University of Surrey, va ajudar significativament a reduir la selecció de llibres i revistes i suggerint la British Library com a recurs suplementari.

En el segon estudi de cas, s'analitza la implicació de Lewis Carroll en diferents tipus d'enigmes, tant dins de les seues obres literàries com de les seues aportacions matemàtiques. La doctora Francine Abeles, professora emèrita de Matemàtiques i Informàtica de la Universitat de Kean, Estats Units, va ser contactada per confirmar el desenvolupament i l'adaptació d'alguns xifrats de Carroll per a aquesta tesi.

En el tercer cas d'estudi, Ada Lovelace va presentar l'ambició d'anar més enllà de pensar i practicar per intentar passar d'una idea abstracta a una aplicació de la vida real. Tot i que es van consultar diversos recursos com és habitual, la major part de la informació per a aquesta anàlisi prové d'una còpia de les *Scientific Memoirs* de Taylor (1843) que es va consultar amb cita a la biblioteca antiga del Magdalen College d'Oxford, així com part de la seua correspondència proporcionada per la Bodleian Library de la mateixa ciutat.

El quart estudi de cas pretenia ser el més pràctic de tots, ja que calia resoldre problemes en una situació d'emergència: la ruptura de la Segona Guerra Mundial. L'èxit de l'exèrcit depenia en gran mesura de les habilitats de l'equip de Bletchley Park, una institució de trencament de codis que analitzava la comunicació secreta durant el conflicte. A partir d'una visita al centre de Milton Keynes i d'una reunió amb el Dr. David Kenyon, un

historiador expert en investigació del Bletchley Park Trust, es va obtenir una comprensió més profunda del seu ús de la resolució de problemes.

Estada internacional

Durant l'estada d'investigació a la University of Surrey, hi va haver reunions mensuals amb la professora supervisora Dra. Patricia Pulham per tal de marcar objectius, suggerir correccions i plantejar dubtes si n'hi hagués. També era obligatori presentar un informe mensual abans del final de cada mes on la doctoranda exposés el que ja s'havia tractat durant la reunió. Aquest informe es va completar a través de l'entorn virtual d'aprenentatge de la universitat (SurreyLearn) i es va transmetre a la supervisora, l'aprovació del qual va ser necessària. Totes les reunions i els informes van ser satisfactoris.

L'estada a Surrey no només va ser una oportunitat per revisar i millorar la qualitat de la tesi fins al moment, sinó que també va ser convenient aprofundir en els casos pràctics. Els recursos eren el doble, i les visites a altres biblioteques i les reunions amb professionals no s'haurien pogut fer sense una afiliació a una universitat britànica. La nota G, la part específica d'un document on Ada incloïa el seu treball sobre els passos inicials per al primer algorisme, havia d'estar disponible a la Biblioteca Bodleian d'Oxford, però la còpia havia desaparegut segons l'equip que es va contactar. Al cap d'unes setmanes, una bibliotecària del Magdalen College, també pertanyent a la Universitat d'Oxford, va confirmar que hi havia un exemplar disponible amb la referència Daubeney 90.A.11. Com que aquesta formava part de les col·leccions especials, l'accés als manuscrits i arxius durant el trimestre estava limitat als estudiants de doctorat i investigadors, i només els dimarts i dijous de 9.30 a 12.30 i de 14 a 16 hores amb reserva cita prèvia. Gràcies a l'afiliació a la University of Surrey durant l'estada de recerca, es va permetre consultar les notes de Lovelace el 23 de novembre de 2023 de 10:30 a 12:30 h. La consulta i citació en persona d'una còpia de l'obra original, a la qual és extremadament difícil d'accedir en línia, va ser supervisada per un membre del personal del Magdalen College, que va proporcionar un escriptori i es va quedar a la biblioteca antiga per obtenir

més ajuda. La visita es va registrar com a referència futura.

Per tal d'aconseguir la tarjeta de lector per a la Bodleian Library, es va portar un conjunt de documents a l'oficina d'admissions, on l'usuari també havia de fer un vot en la seua llengua materna que implicava la conservació de documents i manuscrits. Part de la correspondència de l'Ada es va consultar de 14 a 16 hores a la Weston Library. Quan es consulta per primera vegada arxius i manuscrits moderns, es demana a l'usuari que ompli un formulari de condicions d'accés relacionat amb la Llei de Protecció de Dades de 2018 (Regne Unit), la legislació sobre drets d'autor i la fotografia digital personal. La Dra. Patricia Pulham, la supervisora de la University of Surrey, va facilitar un contacte de la Universitat d'Oxford, el professor Stefano Evangelista, que amablement va oferir una habitació per passar la nit a la universitat si calia.

A principis d'octubre es va enviar un correu electrònic a Bletchley Park per preguntar si era possible parlar amb algú sobre la resolució de problemes i el paper de la dona a la institució, ja que es disposava de poca informació a Internet o a les biblioteques que s'havien consultat. Un membre del personal va redirigir aquest correu electrònic al Dr. David Kenyon, que va acceptar reunir-se i ajudar amb la investigació. El 15 de novembre de 2023 es va fer una visita al centre a les 10.30 hores, seguida d'una reunió de dues hores amb ell a les 11 hores. La seua experiència, que es remunta a l'obtenció del seu doctorat i de múltiples publicacions sobre la Primera Guerra Mundial i la Segona Guerra Mundial, va ser un recurs valuós que va elevar significativament el contingut d'aquesta tesi.

Actualment, Bletchley Park és un museu que obre tot l'any (excepte els dies 24, 25 i 26 de desembre) i es recomana als visitants que deixen un temps mínim de 4-5 hores a un dia complet per passar a les instal·lacions, que inclou visites opcionals, una cafeteria i una tenda de regals. En el moment d'escriure aquest article, l'horari és de 9:30 a 16:00 durant la temporada d'hivern (1 de novembre-28 de febrer) i de 9:30 a 17:00 durant la temporada d'estiu (1 de març-31 d'octubre) (14:00 i 15:00 sent les darreres entrades, respectivament). Les visites individuals o grupals —incloent els col·legis— es poden concertar a través del seu web oficial o comprar les entrades *in situ*, tot i que es recomana la primera.

Criteris d'ensenyament a l'aula

Tot i que la tesi es basa principalment en un enfocament qualitatiu i inductiu de les dades, hi han alguns resultats quantitatius per a l'experiència de l'aula: aquesta sessió es va pensar com una aproximació inicial a com es podria animar els estudiants a crear les seues pròpies idees quan es donen un conjunt de situacions, desenvolupant les seues habilitats de resolució de problemes en el procés. No es pretenia en cap cas servir com a representació definitiva del poder de donar un conjunt d'enigmes a un grup de persones, sinó més aviat un intent d'impartir una classe que va més enllà del pla d'estudis perquè els estudiants pensen de forma no convencional. No només van poder gaudir de la classe, sinó que també van desenvolupar habilitats per resoldre problemes en un entorn dinàmic i de manera pràctica.

Els estudiants de la classe de *Philosophical texts in the English language* (Codi 33252) no tenien el nivell que s'esperava, equivalent a un certificat d'anglès B1 segons el Marc Europeu Comú de Referència per a les llengües: aprenentatge, ensenyament, avaluació (MECR) a causa de diverses circumstàncies. El pla inicial d'introducció teòrica i pràctica a la resolució de problemes distribuïda entre dues classes va haver de ser readaptat al seu nivell, fet que va reduir notablement l'abast de l'experiència. Dividits en dos grups ja que hi havia més de 50 alumnes inscrits al curs, es va impartir una lliçó al grup 1 el dilluns i al grup 2 el dimarts. D'aquesta manera, podrien treballar principalment en equip i oferir-se ajuda entre ells si algú no se sentia segur de les seves habilitats en anglès. La intenció en aquesta ocasió era adoptar un enfocament obert i lleuger als problemes que havien de resoldre i ser tolerants amb les respostes. Al final, es va repartir una enquesta per tal de poder recollir alguns resultats com a mostra.

10.1.3. Resultats generals

El resultat d'aquesta investigació proporciona una visió de la relació entre la literatura britànica —com qualsevol cosa que es pot *llegir*, no només com a ficció— i el desenvolupament d'habilitats de resolució de

problemes per a una Ciutadania Global, tal com fomenten els ODS de les Nacions Unides (Domene Benito & Haba Osca, 2022). La necessitat humana d'esbrinar misteris ha estat present des del principi dels temps, per la qual cosa és natural investigar-ne els beneficis i l'abast que poden assolir. Al llarg d'aquesta tesi, la importància de construir un conjunt fort d'habilitats transferibles per als problemes globals actuals es mostra a partir de la presència històrica de la resolució de problemes a la literatura.

D'acord amb la hipòtesi, la connexió entre ambdues sembla evident: lluny de ser una pràctica que es va mantenir a l'època victoriana, la resolució de problemes apareix tant en qüestions serioses com en contextos més alegres com la indústria de l'entreteniment; n'hi ha artistes de hui dia als quals es va transmetre aquesta tradició. Això vol dir que el desenvolupament d'aquesta habilitat no només va ser fonamental en el passat, sinó que encara atrau l'atenció de l'audiència avui dia (Egenfeldt-Nielsen, 2013; Dietrich et al., 2021). Situada avui com una de les més demandades dins del lloc de treball, pot cobrir un ampli ventall de situacions, des de canviar de ruta fins a anar a correus quan hi ha una congestió fins a enamorar-se fins que fa mal, sagna o s'esvaeix amb el temps.

Aquests resultats són rellevants perquè el nucli holístic de la resolució de problemes va més enllà d'una situació específica (complexa) per dissenyar un context de treball que permeti a la persona resolutora gestionar qualsevol tipus de situació complexa (Espinosa i Walker, 2011). En altres paraules, poden ser capaços de tenir èxit en situacions que no són idèntiques a les que han viscut abans des d'una perspectiva oberta i amb recursos. És precisament a través d'aquesta transferibilitat i adaptabilitat que entren en joc els ODS, ja que la pràctica d'enigmes literaris permet l'activitat en determinades àrees neurològiques que actuaran com una esponja de memòria. Això podria obrir el camí per a un enfocament més fàcil la propera vegada que una persona es troba amb una situació similar.

Presentar-se amb una situació que la persona resolutora no està segura de com tractar es basa en la neuroplasticitat i la capacitat de recordar experiències passades que poden ajudar a la nova (Raskin, 2011; De Oliveira, 2020). Si no hi ha cap base per aprendre, o si hi ha una

manca total de recursos per part de la persona resolutora, el problema romandrà sense resoldre: per tant, com més experiències es tinguen, més probabilitat hi haurà de reunir informació que podria ser transferida més endavant (Chen et al., 2023; Molnár i Greiff, 2023). Tot i que és estrany predir quines dades seran més convenients en el futur, no és necessari preveure una aplicació específica perquè el procés d'aprenentatge siga avantatjós. Al contrari, podria proporcionar a la persona resolutora una varietat més àmplia d'eines per gestionar les circumstàncies personals i professionals (Robertson, 2016).

Fomentar el pensament crític, la presa de decisions, la tolerància, l'enginy, la creativitat i l'obertura cap a les perspectives dels altres són només alguns dels factors que impliquen la resolució de problemes, una habilitat complexa que pot esdevenir un canvi de joc si es juga bé i correctament (Sen, 2011; Birgili, 2015; UNESCO, 2023b). Una vegada més, això es podria desenvolupar a través de múltiples disciplines (Gardiner, 2020), com ara esbrinar quin perill suposa un bacteri mirant el microscopi i entrecreuant dades d'organismes de vida lliure anteriors o assegurar la pau internacional establint relacions justes per tots els partits de la política. Per tant, aquest estudi no limita les possibilitats de resolució de problemes, sinó que millora com es podria aconseguir des d'una perspectiva interdisciplinària i reconeix el poder de cada camp per ajudar en aquesta missió.

Resolució de problemes: casos pràctics

Culturalment parlant, l'època victoriana i principis del segle XX tenien la connexió més òbvia amb els enigmes, les dades d'aquesta tesi contribueixen a una comprensió més clara d'aquest període de temps específic dins d'un context literari més ampli. L'ajustament social en constant canvi a les tecnologies revolucionàries, així com l'acceptació i la curiositat cap als despertars espirituals coexistien en el mateix espai (Noakes, 2004; Andrick, 2023). Aquesta situació va augmentar el gust per rastrejar pistes que conduïen a la solució d'un misteri més gran.

El cas Sherlockià mostra com pensar en totes les possibilitats abans d'actuar davant una situació és un pas clau a l'hora de resoldre un cas.

A la vida real, això és similar al que fa un algorisme informàtic, però a nivell humà: examinar totes les vies que hi pot haver per abordar un problema i trobar la millor alternativa reduint les probabilitats que passe un esdeveniment (Schnotz et al., 2010). Tot i que cada perspectiva és subjectiva fins a cert punt, i qualsevol persona resolutora estarà esbiaixat per molts factors com ara experiències prèvies, el seu entorn i la personalitat, fer un pas enrere i pensar en racionalment sobre una situació (per exemple, recollir detalls d'una situació i relacionar-los amb la informació emmagatzemada) pot ajudar a processar la nova. Si l'intent inicial falla, potser caldria considerar altres explicacions que al principi semblaven poc probables. Algunes solucions per als ODS han estat efectives, però n'hi ha d'altres que no han aconseguit els objectius de l'ONU (Leal Filho et al., 2020; Takyi et al., 2021; Fulzele et al., 2021; , 2022; Perkins et al., 2022). Per tant, aquests intents haurien de ser reavaluats tenint en compte el context, com ara la varietat de recursos dins dels països, on no es pot aplicar la mateixa mesura i haurien de respondre a les seves pròpies necessitats i preocupacions d'una manera més justa (Ferguson et al., 2018).

Lewis Carroll serveix com a model per a la seua participació en la resolució de problemes. Sense obsessionar-se massa, el seu cas es pot aplicar a la vida real gràcies a la seua visió innovadora del coneixement, decidit a treballar al voltant d'alguna cosa que no podria resoldre en lloc de sucumbir a la derrota (Gardner, 1996; Moktefi, 2018). Si sentia que disposava de recursos mentals, intentaria trobar vies per donar llum a un misteri no resolt, de vegades amb èxit i de vegades fracassat, però tot va contribuir al seu procés d'aprenentatge al llarg de la vida. Conscienciar sobre els ODS a l'aula des de ben jove i estudiar què no ofereixen les solucions actuals analitzant i practicant problemes similars en el passat podria evitar que la humanitat cometi els mateixos errors en les dècades següents (Haba Osca, 2023). Aquest objectiu, però, només es pot assolir amb un treball dur i amb expectatives realistes del que es pot fer ara.

Ada Lovelace representa el pont entre la teoria i l'aplicació de les dades a la vida real, i va decidir que tots els anys que havia passat aprenent s'havien de convertir en quelcom material, pràctic. Va veure diferents

campes del coneixement com a interconnectats i va animar els lectors a anar més enllà dels límits per descobrir patrons i establir relacions entre ells (Strawn, 2023). La seua actitud encarna el coratge que es necessita per pensar de forma poc convencional, demostrat pel seu intent de redactar un prototip del primer algorisme adaptant conceptes del passat amb l'esperança que pogueren canviar el futur. Reconeixent la importància de l'assaig i l'error, el procés d'aprenentatge es considera útil en cada pas per a la matemàtica, que no va desanimar el seu esperit quan s'enfrontava al fracàs (Lovelace, 1843). Si no hagués experimentat aquests errors i no hagués anat més enllà de la traducció de la qual s'encarregava per escriure la seua pròpia producció, hui dia s'hauria perdut una important contribució a la informàtica (Charman-Anderson, 2020). Tot i que trobar l'equilibri entre la set d'innovació i una mentalitat realista és un tema fràgil, aquest estat de gràcia permet l'anàlisi racional d'una qüestió alhora que deixa espai perquè les idees creixen.

Des de moments desesperats fins a la necessitat d'una acció immediata, el treball a Bletchley Park s'assembla més a la urgència de desenvolupar la resolució de problemes per als ODS. Les vides de molts estaven en perill i sovint depenien de la capacitat dels encarregats de desxifrar els codis per anticipar cada moviment i actuar per evitar que una catàstrofe es produís abans que fos massa tard (Millward, 1993; Smith, 2021). Les tècniques que utilitzaven eren moltes, però incloïen posar-se a la pell de l'enemic per veure la mateixa situació des d'una altra perspectiva i tenir una forta capacitat de presa de decisions que els permetia prioritzar unes tasques per sobre d'altres (Kenyon, 2019). Tot i que les circumstàncies són completament diferents, i amb sort s'eviten paraules com "enemic" en el viatge cap a un planeta millor, la seua cooperació era essencial per actuar junts contra la mateixa amenaça. En posar una vida justa per a tothom en primer lloc i treballar en equip per assolir objectius comuns, aplicar la resolució de problemes es converteix en una activitat més fàcil que pot ajudar a garantir una vida tranquil·la.

Resolució de problemes a la pràctica en un entorn d'educació superior

La lliçó pretenia proporcionar un exemple de com alguns dels estudis de

cas es podrien aplicar a una classe universitària, però no és en cap cas una representació significativa de la influència que podrien comportar. Per tant, la generalització dels resultats està limitada pel nombre d'estudiants que han participat i només serveix com a mostra de com la implementació de material dinàmic podria afectar el desenvolupament de les habilitats de resolució de problemes. A causa de la manca de dades sobre l'efecte neurològic que podria tenir fer aquestes activitats de manera regular, els resultats no poden confirmar fins a quin punt podrien ser beneficioses a llarg termini. No obstant això, la hipòtesi és que, donat el camí històric i l'interès natural per la resolució de problemes, així com els efectes provats sobre el cervell humà que van mostrar estudis anteriors, probablement podrien convertir-se en una eina per fomentar aquesta capacitat.

Els resultats suggereixen que els alumnes van gaudir d'una lliçó animada que els va permetre treballar en grup mentre elaboraven les seues idees. Tot i que l'educació no és el tema principal d'aquesta tesi, i la vida és una experiència d'aprenentatge llarg, i una part important de l'adquisició de coneixements s'inicia des dels anys escolars i universitaris. Per això, es va considerar que aquest experiment era adequat. Pretendent ser un indicador de potencial, insinua la possibilitat d'introduir aquesta habilitat des d'una perspectiva pràctica més que no pas purament teòrica, i assegurar-se que els estudiants estiguen preparats per afrontar i superar un entorn agitat que inclourà els perills de no complir els ODS a temps (Haba Osca, 2023).

10.1.4. Conclusió

La tesi doctoral va concloure que la millora de les habilitats de resolució de problemes és essencial per gestionar situacions quotidianes, però també serveix com a eina per abordar grans qüestions com els ODS de les Nacions Unides. Els estudis futurs haurien de tenir en compte la sostenibilitat a l'hora de fer recerca, ja que és una aplicació actual de la vida real que afecta la vida de tothom. Tot i que aparentment no té relació al principi, aquest estudi mostra com unir camps de coneixement com la literatura i la Ciutadania Global és una forma interdisciplinària d'entendre l'aprenentatge. Ser un ciutadà global implica un entendiment

de les diverses realitats, i els problemes que afecten a tothom. En aquesta realitat, és imprescindible establir connexions entre situacions i recordar un flux continu d'informació d'experiències passades, en lloc d'adherir-se rígidament a una sola disciplina.

Només aquesta tesi doctoral no pot cobrir les necessitats dels ODS, i hi ha un nombre creixent d'articles que intenten contribuir al seu estudi, però encara hi ha una manca de recursos i consciència de la importància d'aquestes habilitats. Un estudi neurològic sobre com reacciona el cervell quan està exposat a diferents tipus d'activitats que requereixen la resolució de problemes hauria estat un gran recurs complementari, però la manca d'ajuts econòmics no va permetre fer-ho. Es necessiten més investigacions per establir totes les relacions entre l'activació de diferents àrees dins del cervell a l'hora de realitzar aquestes activitats.

Les vies per a futures investigacions inclouen la incorporació d'altres disciplines a la carrera cap a la Ciutadania Global i la sostenibilitat, posant sobre la taula la interdisciplinarietat i, per tant, un enfocament més realista per superar els obstacles en el camí. Tenir un grup de control que realitzi activitats pràctiques de resolució de problemes abans de tenir una discussió sobre els ODS pot fer que tinguin més èxit en el seu enfocament que la pluja d'idees d'un grup que no ha practicat abans, però això s'ha de provar més vegades perquè la hipòtesi siga confirmada. Aquesta tesi va més enllà de la terminologia abstracta per situar l'adquisició d'aquestes habilitats a través d'enigmes literaris com una de les fórmules d'una Ciutadania Global, sens dubte una de les aplicacions més tangibles que podrien tenir en aquest període de temps.

10.2. Class syllabus

COURSE DATA

Data Subject

Code	33252
Name	Philosophical texts in the english language
Cycle	Grade
ECTS Credits	6.0
Academic year	2022 - 2023

Study (s)

Degree	Center	Acad. Period year
1012 - Degree in Philosophy	Faculty of Philosophy and Educational Sciences	2 Second term

Subject-matter

Degree	Subject-matter	Character
1012 - Degree in Philosophy	5 - Modern language	Basic Training

Coordination

Name	Department
ARENAS LLOPIS, LUIS	359 - Philosophy

SUMMARY

The course *Philosophical Texts in English* focuses on a specific use of the English language: the philosophical use. We will study the terms through which different philosophical concepts are expressed. These terms will not be studied in isolation but rather in the context in which they arise and become fully meaningful. Our goal is to provide university students with the minimal knowledge and linguistic tools that are necessary for a better and more comprehensive understanding of English texts with philosophical content.

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

There are no specified enrollment restrictions with other subjects of the curriculum.

Other requirements

No se requieren conocimientos previos.

OUTCOMES

1004 - Degree in Philosophy

- Que los estudiantes hayan demostrado poseer y comprender conocimientos en un área de estudio que parte de la base de la educación secundaria general, y se suele encontrar a un nivel que, si bien se apoya en libros de texto avanzados, incluye también algunos aspectos que implican conocimientos procedentes de la vanguardia de su campo de estudio.
- Be able to apply knowledge to work in a professional manner and have competences for preparing and defending arguments and for solving problems within the field of study.
- Students must have the ability to gather and interpret relevant data (usually in their field of study) to make judgements that take relevant social, scientific or ethical issues into consideration.
- Students must be able to communicate information, ideas, problems and solutions to both expert and lay audiences.
- Students must have developed the learning skills needed to undertake further study with a high degree of autonomy.
- Capacidad de comunicación profesional oral y escrita en las lenguas propias de la Universitat de València.
- Be able to communicate in a foreign language.
- Be able to obtain information from different primary and secondary sources.
- Be able to analyse, synthesise and interpret relevant cultural, social, political, ethical or scientific data, and to make reflective judgements about them from a non-androcentric perspective.
- Be able to communicate with experts in the area of knowledge and in other areas.
- Be able to apply knowledge to practice.
- Be able to learn autonomously.
- Acquire a basic knowledge of the problems, texts and methods that philosophy has developed throughout its history and recognise possible androcentric biases.
- Be familiar with the ideas and arguments of the main philosophers and thinkers, extracted from their texts, and with the investigation of their traditions and schools, identifying the possible androcentric biases.



- Use and rigorously analyse specialised philosophical terminology.
- Acquire the learning skills needed to undertake further studies with an increasing degree of autonomy.
- Work with an increasing degree of self-motivation and self-demand.

LEARNING OUTCOMES

The main goal of the course Philosophical Texts in English is to introduce the students to some of the most important and influential philosophical traditions that come from the Commonwealth and the United States of America, taking into account their major representative figures, concepts, and methodological approaches. Another goal of the course is that students learn to master academic English as applied to the field of Philosophy, and that they develop the skills for academic work in English. More specifically, that they develop their reading understanding and written expression abilities.

DESCRIPTION OF CONTENTS

1. The writing of argumentative philosophical texts and argumentation techniques argumentative techniques

Introduction to the techniques for the identification of arguments in English texts.

Introduction to the techniques for the preparation of summaries and short argumentative essays

2. The philosophical English of the XVII and XVIII centuries

Critical analysis and translation of texts that are representative of the philosophical English of the XVII and XVIII centuries, with special emphasis in the identification, reconstruction and evaluation of arguments.

3. The philosophical English of the XIX century

Critical analysis and translation of texts that are representative of the philosophical English of the XIX century, with special emphasis in the identification, reconstruction and evaluation of arguments.

4. The philosophical English of the XX century

Critical analysis and translation of texts that are representative of the philosophical English of the XX century, with special emphasis in the identification, reconstruction and evaluation of arguments.

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	30,00	100
Seminars	15,00	100
Tutorials	5,00	100
Development of individual work	20,00	0
Readings supplementary material	5,00	0
Preparation of evaluation activities	75,00	0
TOTAL	150,00	

TEACHING METHODOLOGY

THEORETICAL LECTURES

These lectures, arranged in different thematic units, will be focused on a selection of English texts, which will be carefully read and analyzed in their intrinsic aspects, paying special attention to the terms in which philosophical concepts are expressed. The texts will be provided by the professor. The lectures will be delivered in English by the professor and students are encouraged to participate. They will be mostly expository sessions in which the basic topics will be introduced. Students should attend these lectures having read the material in English that the professor will indicate for each session. Before the lecture, the students should have written in English an outline and summary of the text. Students will actively participate in class, presenting the results of their written work on the topic and taking part in the ensuing discussion that will arise from the different ideas and views expressed by the rest of the class.

PRACTICAL SESSIONS

Before the session, the students will have to read a text in English, related to the topic presented the corresponding theoretical lecture. During the practical session, they will translate fragments from the English text to their own language (i.e., one of the two official languages in the region). Afterwards,



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Course Guide**33252 Philosophical texts in the english language**

they will express their views on different aspects of the text and they will participate in a debate about some of the main ideas suggested by the text. In this discussion, students may use either English or their own language.

SUPERVISED WRITTEN WORK

During the course, students will write in English an outline and summary of each of the theoretical topics discussed in the expository lectures.

TUTORIALS

At the tutorials, the student's written work will be reviewed and supervised.

EVALUATION*First call*

The assessment will involve a final written test and a series of continuous assessment activities (written work, presentations and classroom exercises) carried out during the course. The final written test and the activities proposed in the Theory lectures will determine 70% of the final mark, while the activities proposed in the Practical Classes will determine the remaining 30%.

Second call

The second call assessment will involve a final written test on the whole syllabus that will determine 100% of the final grade.

REFERENCES

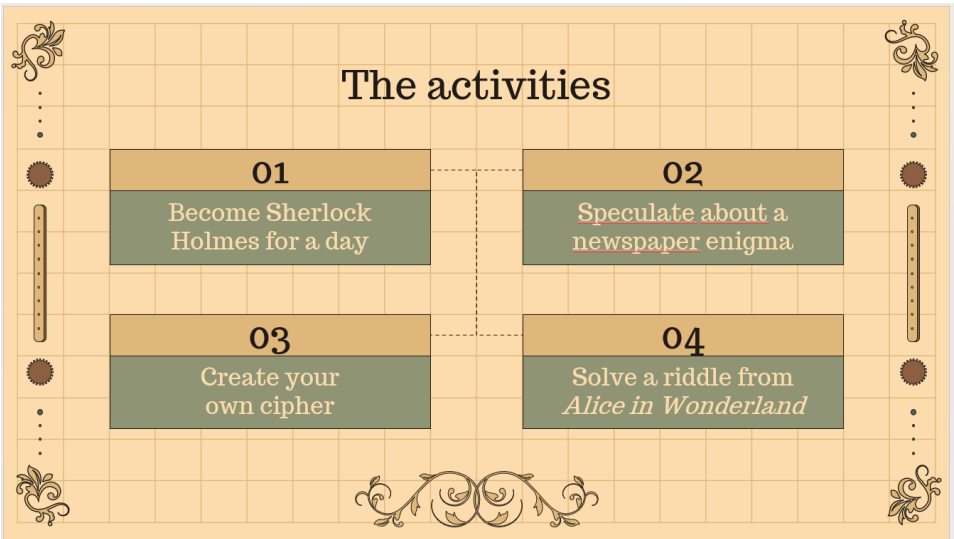
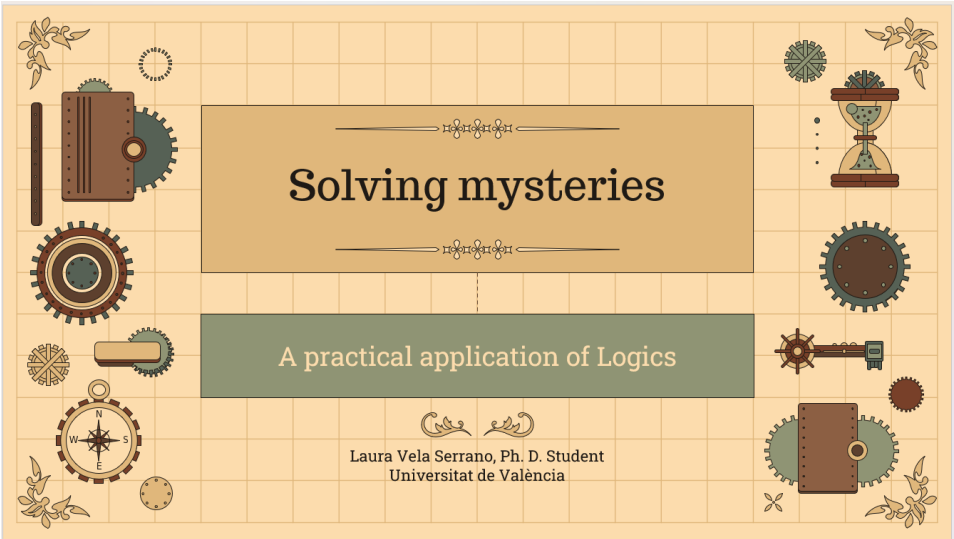
Basic

- Se especificarán los textos en lengua inglesa de los autores tratados en clase.

Additional

- Stanford Encyclopedia of Philosophy
<http://plato.stanford.edu/>
Routledge Encyclopedia of Philosophy
Servicio de Bibliotecas y Documentación de la Universidad de Valencia
Debating Skills http://www.actdu.org.au/archives/actein_site/basicskills.html
Writing an Outline
University of Washington Psychology Writing Center
<http://depts.washington.edu/psywc/handouts/pdf/outline.pdf>
Writing a Summary
<http://www.sdc.uwo.ca/writing/handouts/Summary%20Writing.pdf>

10.3. Power Point slides



01

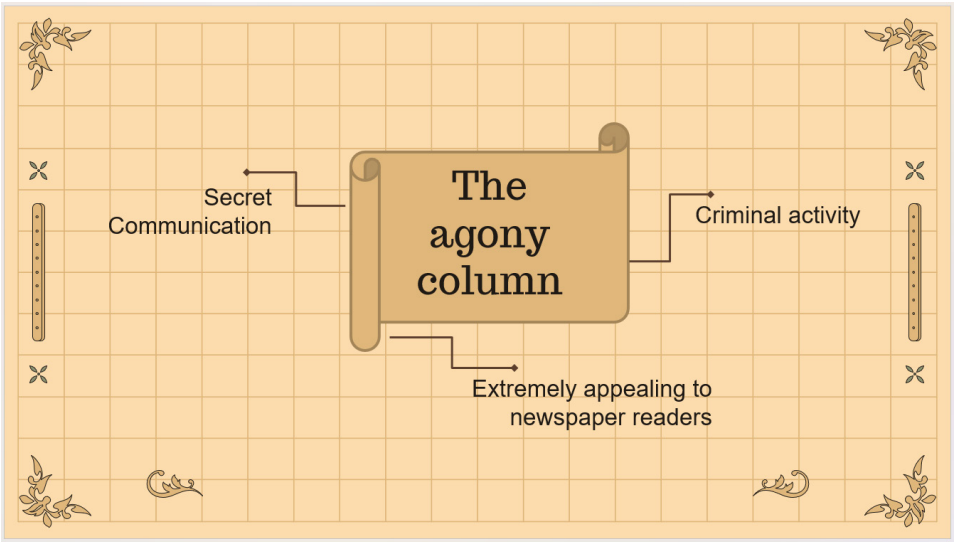
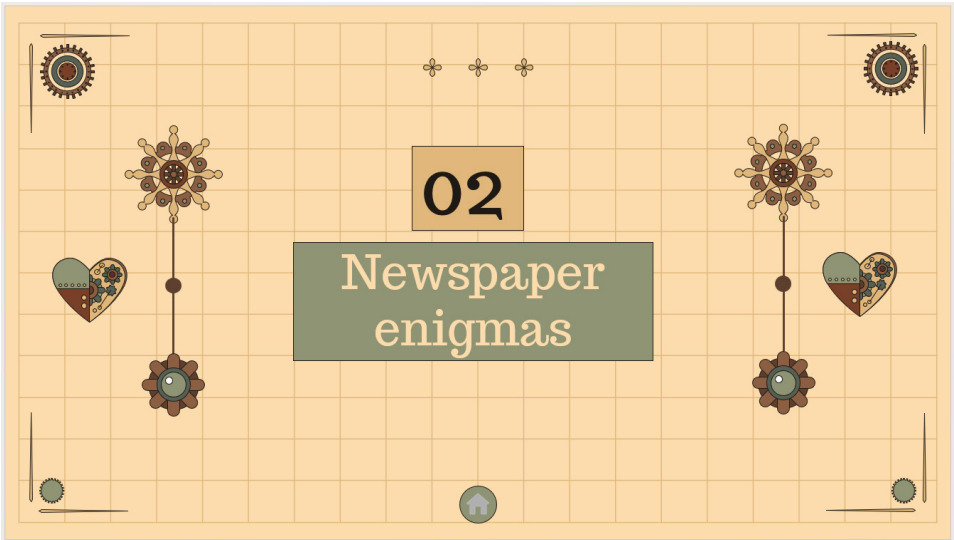
Sherlock Holmes uses induction/abduction to solve his cases.

This time, it's gonna be you the ones that must solve a crime...

Become Sherlock Holmes for a day

Activity 1: The crime scene

As seen on Series 1, Episode 1 of *Sherlock Holmes* BBC, 'A Study in Pink'



Activity 2:
A suspicious message

«To James. Meet me this afternoon at the bakery
at Macclesfield road in Holmes Chapel.
Augustine is well again. Betty.»

03 Ciphers

Really important during the war
The army could send secret messages
to each other through a code

An example of an easy cipher



Substitution by moving 3 letters forward

So, if we wanted to say "MIDNIGHTS",

the cipher would become "PLGQLJKW"

Activity 3: Create your own cipher

Change my substitution method

As much as you want to

Explain how you created it

What method did you follow and why?



04 *Alice in Wonderland*

"Why is a raven like a writing desk?"

—The Hatter, 'A mad tea-party'

Theories

- ◆ A raven eats worms, while a writing desk is worm-eaten
- ◆ Both the raven and the writing desk produce notes (as in the preface by Carroll)

but there is actually no set answer...
so what's your guess?

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- ◆ Both the raven and the writing desk produce notes (as in the preface by Carroll)

but there is actually no set answer...
so what's your guess?

10.4. Full responses from students

This responses are not modified, but taken as students submitted them.

10.4.1. Group 1

Activity 1: The crime scene

The woman was murdered, and before she died she wrote on the floor the name of the killer, with the blood of her wound. Also, she used her ring to tear the ground, this is why his ring was dirty.

Activity 2: A newspaper enigma

It may be an alibi if within that betty is the murder and the message contains a hidden information. Another option, is to think that Betty was killed by James or Agustin, and they wrote this message and published it in order to cover her death and make people think that she is still alive.

Activity 3: Create your own cipher

We propose to substitute each letter for a number, following the natural order of both. For example, A is number 1, and Z is number 26. So, if we want to write 'Liberty', it would be the following sequence: 12-9-2-5-18-20-25.

Activity 4: "Why is a raven like a writing desk?" from *Alice in Wonderland*

Both a raven and a writing desk can be used as tools for thinking and creativity. A raven is a very intelligent bird that is often associated with wisdom and cunning. On the other hand, a desk table is a place where people can sit to write, draw, think and plan.

10.4.2. Group 2

Activity 1: The crime scene

In a small village in Germany (because the word wick is written on the

floor is in german) a husband killed his wife in revenge. The officials find her in an empty house. They also find a wedding ring that presumably belongs to the husband, as she still wears hers on her finger. He has carved the word revenge into the ground, which suggests that this was the reason for the murder.

Activity 2: A newspaper enigma

Betty (who is not actually called Betty) communicates with her secret lover 'James' (who is probably not called James either). In order to keep the affair secret, they communicate anonymously via the newspaper, as telephoning or a house call would be too conspicuous. It is about a secret sex meeting because 'Augustine' (her vagina) has recovered after the last time.

Activity 3: Create your own cipher

Substitution by moving 1 letter back: 'RDBQDS KNUDQ'

Activity 4: "Why is a raven like a writing desk?" from *Alice in Wonderland*

The raven can be used as a carrier pigeon by teaching it to deliver messages. The desk is also used to create messages. Both types of messages are in written form, which connects the two. If it is a black desk, the connection fits even better.

10.4.3. Group 3

Activity 1: The crime scene

It is not the same ring, the one analyzed is different from the one you have. And the nails are not painted on the other hand. One of the analyzers suspects samples.

Activity 2: A newspaper enigma

James and Betty and they had planned the murder of Agustín in the bakery but it turns out that Rache would go instead because Agustín warned him

and sent Rache, who died in his place. He has to do with a question of Principles and justice for what he puts in the piece of newspaper.

Activity 3: Create your own cipher

Fight / Gymnastic / Money

Imfq/ Ldrsfxynh/ Rtsjd

We didn't change the substitution method so we just move each letter three letters forward or backward.

Activity 4: "Why is a raven like a writing desk?" from *Alice in Wonderland*

The bird is perched on a Branch, the desk is made out of Wood, Wood comes from trees. And the trees have branches, in witch the ravens perches itself.

10.4.4. Group 4

Activity 1: The crime scene

Ist es Rache oder wollte die Leiche den Namen des Mörders oder einen Hinweis festhalten („Rachel")? Der Ring sieht aus wie der Ehering eines Mannes. Der Fakt, dass er innen sauber ist, weist darauf hin, dass er kürzlich getragen wurde. Nachdem sie noch ihren Ehering trägt, kann davon ausgegangen werden, dass der andere Ring ihrem Mann gehört.

Theorie: Die Frau bat ihren Mann sie in diesem auffälligen Haus zu treffen um ihm unbelauscht erzählen zu können, dass sie ihre wahre Identität verschleierte. Ihr richtiger Name war Rachel. Der Mann fühlte sich betrogen und brachte die Frau um. Bei dem Kampf verlor er seinen Ring.

Activity 2: A newspaper enigma

Die Anzeige muss eine geheime Nachricht enthalten, weil es keinen Sinn ergibt, dass eine Bewohnerin von dem Ort eine Anzeige schaltet, um ein Treffen zu vereinbaren und noch dazu den Ort der Lokalzeitschrift

erwähnt, obwohl die Bäckerei den Bewohner*innen wohl bekannt sein müsste.

Activity 3: Create your own cipher

Exchange the inner circle with numbers. So MIDNIGHTS would be 13 9 4 14 9 8 9 20 19

Activity 4: “Why is a raven like a writing desk?” from *Alice in Wonderland*

Both contain feathers, one for writing, the other to fly.

10.4.5. Group 5

Activity 1: The crime scene

The murderer killed the woman. Once she was dead, he removed her ring and wrote the word ‘rache’ with the victim’s blood on the outside of the ring. In this way, his fingerprints are not left on the floor. Therefore, we deduce that the death is not accidental and the letters are a message from the murderer. Perhaps these letters are a signature of the killer or a way of listing his victims. Therefore, it can be deduced that this is not an isolated case and the killer is a serial killer.

Activity 2: A newspaper enigma

Betty and Augustine are a married couple. Betty has been unfaithful to Augustine with James for one year and Augustine has found out. Betty had been telling James that Augustine was terminally ill and could not be saved. Therefore, they could be free and together by the time Augustin died. Augustin had found out everything by reading the letters between the lovers.

In a rage, he has killed his wife Betty and intends to do the same to James. Therefore, he poses as Betty in the newspaper so that James will come to the appointment and have the opportunity to take revenge. With this particular message, she made sure that James would go to the meeting without suspicion.

Activity 3: Create your own cipher

A: A	B: E	C: P	D: T	E: Y
F: Θ	G: I	H: O	I: Π	J: A
K: Σ	L: Δ	M: Φ	N: Γ	Ñ: H
O: Ξ	P: K	Q: Λ	R: Z	S: X
T: Ψ	U: Ω	V: B	W: N	X: M
Y: ∇	Z: ∃			

Example: OYZΦΖΓΖΩΨΠP > Hermeneutic

Activity 4: “Why is a raven like a writing desk?” from *Alice in Wonderland*

Why is a raven like a writing-desk? Both tell stories: the crow with its song and the desk with its letters. Moreover, both exist. Both can be black and used by men. Both need trees: the crow to be born and the desk to be created.

10.4.6. Group 6

Activity 1: The crime scene

The woman was found dead on the floor with his hand laying in a position in which her index finger connects directly to the name written on the floor. Inspecting her ring, Holmes notices that the inner part of it was clean, whilst the external part was dirty. The name marked on the floor shows that half of it was carved with the ring, but the other half is written with dirt.

It would have been impossible for her to write the murderer’s name with dirt while being killed. However, she could have started writing it with

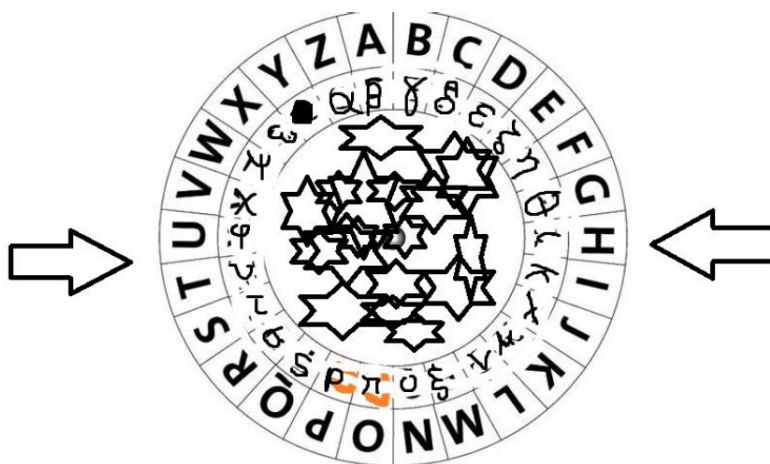
the ring before being attacked, probably at the time she was hiding from her murderer. Then, when the murderer came and killed her, he or she probably saw the attempt of the victim to make his or her name known. This is why half of the name was covered in dirt, so that investigators would think that she was killed by this person, which the murderer presumably hated. Then, he or she placed her finger next to the writing to make the scene believable.

Activity 2: A newspaper enigma

We could see this one as one anonymous writer warning James that his wife Betty has met at the bakery at Macclesfield road with someone who's called Augustine, implying that Betty is cheating on James with Augustine.

Another interpretation could be that this section of the newspaper is being used by criminals to communicate with the family of the victim they kidnapped. If we think about it, this section can be a very good way for kidnappers to send secret encrypted messages to the loved ones of their victims. Contrary to letters which can be traced, this announcement can be written by anyone, so it would be difficult to state with certainty that what this says is part of a crime, even if the victim knows.

Activity 3: Create your own cipher



We have moved the inner circle one place to the left and we have exchanged the Latin alphabet with the Greek. So, as you can see, if you want to write the word Germán, you should write: θζσξβo

Activity 4: ‘Why is a raven like a writing desk?’ from *Alice in Wonderland*

‘As you can’t see a raven at night, you wouldn’t see me at my writing-desk either’.

10.4.7. Group 7

Activity 1: The crime scene

We believe that the deceased woman was murdered and the key clue is that her ring is dirty on the outside and clean on the inside. However, we cannot ignore that one of the nails of his left hand has damaged nail polish and it is a woman’s name written on the wooden floor. This is what we think happened: the deceased woman, somehow, knew that she was going to be murdered by another woman called Rachel, so she decided to write that name on the floor with his ring (this would explain the reason why the ring was dirty on the outside, but clean on the inside). Nevertheless, by the time she had already written the ‘R’ and the ‘a’, the murderer killed her and quickly fled the scene of the crime. The victim, who was not dead yet, finished writing the murderer’s name with his fingernail, damaging his nail polish.

Activity 2: A newspaper enigma

What we think is that ‘James’ and ‘Betty’ are the pseudonyms used by two thieves who have robbed the Warrington bank (Warrington is a city near Holmes Chapel). After robbing the bank, James hid in Holmes Chapel and Betty kept the money, away from this town. When none of them was in danger, Betty decided to pay the local Holmes Chapel newspaper by post to put the message, because this was the only way to let James know that ‘Augustine’ (the pseudonym used to call the stolen money) was well, without attracting the attention of the police.

Activity 3: Create your own cipher

We substituted by moving six letters forward, so the letter ‘A’ corresponds to the letter ‘G’, the ‘B’ to the ‘H’, the ‘C’ to the ‘I’ and so on. So, if we wanted to say ‘GRENADE’, the cipher would become ‘MXKNGJK’.

Activity 4: ‘Why is a raven like a writing desk?’ from *Alice in Wonderland*

Why is a raven like a writing-desk? On the one hand people sit in front of a writing-desk to write, and writing is a way of transporting a person’s ideas to paper. On the other hand, ravens have been used for many ages to carry written messages. So we think that both, a raven and a writing-desk, are ‘message channels’, it is to say, channels through which a message can be expressed and conveyed.

10.4.8. Group 8

Activity 1: The crime scene

The first thing we have noticed is the difference in the wear and tear of the ring. We have arrived at the conclusion that the woman is used to taking off the ring when she is meeting someone she wants to flirt with. But, in the pictures she is having the ring put on, so the murder is not the lover.

The second thing we have noticed is that there is not blood around the body. That leaves us two options: she has been killed strangled or by overdose. We have decided that she has been murdered by drug intoxication, because she has time to write ‘Rache ‘ on the floor.

Rachel has to be the main point of all this mess up. Maybe the killer or maybe a witness of the crime.

Activity 2: A newspaper enigma

Our first supposition is that James is married to some woman but has an affair. But we think that Betty is a kind of code and not the name of the lover. We think that the lover is not Betty because it does not make sense

that the lover signed the letter with her name.

Another supposition is that James had an affair with Betty, with whom he had a daughter, Augustine. Betty has been asking for money from James, because she needed supplies to take care of their daughter. She writes to the journal to meet James at some point and to tell him that their daughter is getting better and to receive more money from him.

Our third, and last, supposition is that James is hidden for some reason and that is why his wife, Betty, tries to communicate with him. She is trying to tell him that the daughter is recovering from some disease.

Activity 3: Create your own cipher

Meatball $\rightarrow$ 16925144141144144

A $\rightarrow$ 1 B $\rightarrow$ 2 C $\rightarrow$ 3 D $\rightarrow$ 4 E $\rightarrow$ 5 F $\rightarrow$ 6 G $\rightarrow$ 7

H $\rightarrow$ 8 I $\rightarrow$ 9 J $\rightarrow$ 10 K $\rightarrow$ 11 L $\rightarrow$ 12 M $\rightarrow$ 13 N $\rightarrow$ 14

Ñ $\rightarrow$ 15 O $\rightarrow$ 16 P $\rightarrow$ 17 Q $\rightarrow$ 18 R $\rightarrow$ 19 S $\rightarrow$ 20 T $\rightarrow$ 21

U $\rightarrow$ 22 V $\rightarrow$ 23 W $\rightarrow$ 24 X $\rightarrow$ 25 Y $\rightarrow$ 26 Z $\rightarrow$ 27

The method consists in assigning to each letter a value and then multiplying them by themselves, that is to say, the square of each number. The word we have chosen is the name of a secret military operation during WWII.

Activity 4: ‘Why is a raven like a writing desk?’ from *Alice in Wonderland*

A raven is like a writing-desk because both of them are associated with internal and deep thoughts, commonly tetric thoughts, that we externalize via writing. It is common to establish a relationship between tragic writers, such as Shakespeare, and poets, as Edgar Allan Poe, with dark symbology, like ravens. We can also see that ravens tend to be alone and not in a flock of birds, so that we can consider that there is a similarity here due to the fact that when we write, study or do some work in a writing-desk we do it alone.

10.4.9. Group 9

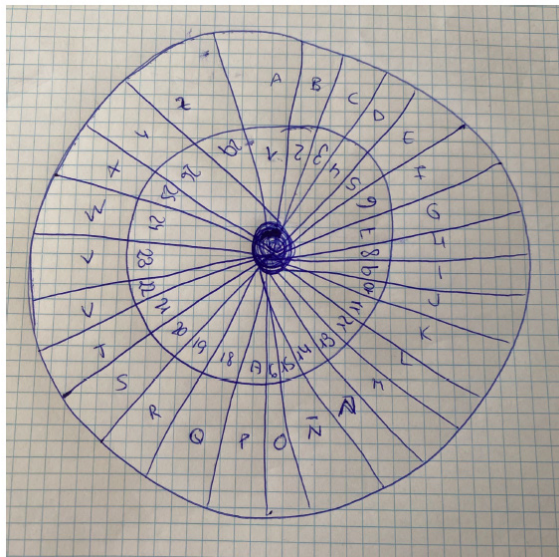
Activity 1: The crime scene

Rosana and Cristian were married for 20 years. Cristian went with another woman and told Rosana to get divorced and so Rosana had to give her ring back to Cristian. One day, Rosana saw Maria, Cristian 's new wife. In anger, Rosana hit her in order to recover her ring and ended up killing her by accident. Days after Cristian went to Rosana's home to take the ring, they both got violent and Cristian assassinated Rosana and wrote Rache using the mentioned ring.

Activity 2: A newspaper enigma

Augustine is an acronym that covers up another person. We do not know who is exactly back from that name, but Betty and James have her kidnapped. Augustine can not die because they want to earn the reward.

Activity 3: Create your own cipher



Activity 4: 'Why is a raven like a writing desk?' from *Alice in Wonderland*

They are almost the same. Some days you can not even distinguish a raven and a writing-desk. For example, the raven scratches the crop as

well as the desk scratches the writer's mind. Also, the raven has been as good as the desk to write novels, for example, the Raven of Allan Poe. But the most important similarity is that when you stomp them both, the raven and the desk creak.

10.4.10. Group 10

Activity 1: The crime scene

The dead woman was killed by a woman named Rachel. She tried to write the name of the murderer, but the only thing she could find to do it was one of the rings she was wearing. She used the ring to carve the name of the killer on the wooden floor, but she could not finish as she died before writing the last letter. The dead woman was able to carve the floor because it was molded and that's also the reason why the ring was so dirty on the outside.

Activity 2: A newspaper enigma

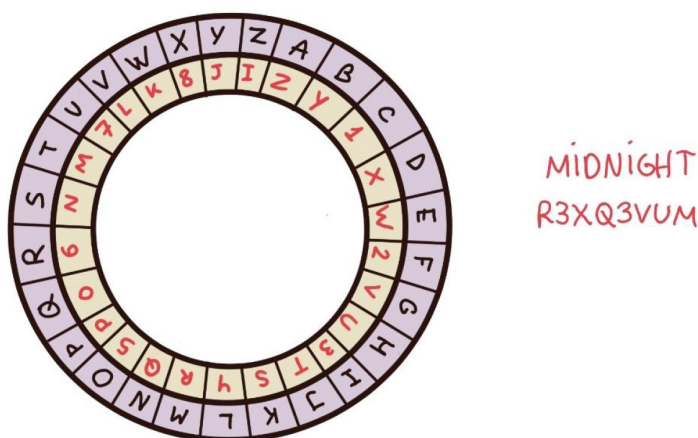
«To James. Meet me this afternoon at the bakery at Macclesfield road in Holmes Chapel. Augustine is well again. Betty.»

The message is addressed to Betty. The one who writes it tells her to go to the completed works of Saint Augustine ('Agustine'); there is a secret message there that she has to read. The following names indicate the place of the message: 'James', which has 5 words, indicates her to take volume 5 of Saint Augustine. 'Macclesfield', which has 12 letters, indicates to go to page 12. 'Holmes', which has 6 letters, indicates to go to paragraph 6. 'Chapel', with 6 letters, indicates to read from word 6. To emphasize this, he uses the term 'bakery': in bakeries, bakers make bread, which is composed by 'B' (from Betty) and 'read', saying: Betty reads the hidden message in volume 5, page 12, paragraph 6, word 6 of the works of Saint Augustine of Hippo.

Activity 3: Create your own cipher

In order to make the code more difficult to discover, we decided to turn the alphabet around so that the Z equals to an A. Then, every two letters,

we added a number to mismatch the letters. This is the end result:



Activity 4: ‘Why is a raven like a writing desk?’ from *Alice in Wonderland*

A raven and a writing-desk have two things in common: First off all, both of them can be found inside of a witch’s hut, and they both are typically associated with witchcraft and spell-making because the writing-desk shown in the picture looks very old and witchy-like, and the raven is normally represented as a witch’s pet or as the witch herself if she can shape shift. The second similarity is that if you set them on fire, they both turn into ashes, even if they are made of different materials (flesh and wood).

10.4.11. Group 11

Activity 1: The crime scene

The woman thought that a neighbor of hers wanted to do something bad to her because he had been watching her for a week. Therefore, when she saw him from the window, she wrote down his name, which begins with ‘che’. The neighbor went up and killed her, and wrote ‘ra’ in front of her name with a ring so that it wouldn’t make sense.

Activity 2: A newspaper enigma

Betty writes to James in the newspaper to arrange a specific meeting place, as she didn't want to go to his house and risk being seen together or people thinking they were plotting something. The two of them have the goal of killing Augustine and are going to meet again today to discuss it further, now that he's feeling better.'

Activity 3: Create your own cipher

We change the letters by his number in the alphabet like 1=a. 2=b or 3=c. To difference 11=aa and 11=k we put a '-', like 1-1=aa, and 11=k. For example 'midnights' is '13-9-4-14-9-7-8-20-19'.

Activity 4: 'Why is a raven like a writing desk?' from *Alice in Wonderland*

Both of them have feather, the raven has feathers all over its skin while the desk has feathers for writing.

10.4.12. Group 12**Activity 1: The crime scene**

The woman lying on the floor was murdered by her husband. We can infer this from the wedding ring the detective found next to her. We can suppose that the woman tried to write the name of the assassin on the floor, with the ring or with her nails, but before she could finish, the husband, that is, the murderer, wrote another name to confuse the detectives. We can suppose this because the first two letters written on the floor are different from the three last ones. Moreover, it seems like the name it's not completed on purpose.

Activity 2: A newspaper enigma

The person that wrote on the paper is having a personal affair with James. Nonetheless he has a wife. This situation can be made public and the only way they can meet it's through an anonymous message. Due to the new technologies not too many people nowadays buy the newspaper, so

the person that wrote this can be sure that there is no danger that the woman finds out.

Activity 3: Create your own cipher

The alphabet is the other way around: Car would be xzi.

A=Z, B=Y, C=X, D=W, E=V, F=U, G=T, H=S, I=R, J=Q, K=P, L=O, M=N, N=M, O=L, P=K, Q=J, R=I, S=H, T=G, U=F, V=E, W=D, X=C, Y=B, Z=A

Activity 4: ‘Why is a raven like a writing desk?’ from *Alice in Wonderland*

When the poet dies just the writing-desk is left, just as the raven is the only thing left when death reaches us. That is why the raven and the writing-desk are alike.

10.4.13. Group 13

Activity 1: The crime scene

The assassin wants the police to believe that the woman tried to write the name of the person who murdered her. Her nail polish is on the letters that are torn on the ground and her index finger lacks of polish. The first two letters don’t have any polish. Furthermore, there is a ring, which is clean on the inside. That means that the ring didn’t belong to the murdered woman, because it would have been dirty on the inside too. So, someone -probably the assassin- put the ring in her hand. Our conclusion is that the person who murdered the young woman wanted to leave fake clues to confuse the police, or maybe that the ring and the name are a signature of a serial killer.

Activity 2: A newspaper enigma

The message is a false alibi to cover up a robber. These people are trying to do something at that exact time and that’s the perfect alibi. The common thing to do in these cases is to secretly follow the three of them, so they don’t do anything suspicious. Maybe it’s a message code and has

nothing to do with persons or places. I guess we never know but I think we have a lack of information or clues to properly follow the case.

Activity 3: Create your own cipher

A	B	C	D	E	F	G	H	I	J	K	L	M
Z	Y	X	W	V	U	T	S	R	Q	P	O	N

N	O	P	Q	R	S	T	U	V	W	X	Y	Z
M	L	K	J	I	H	G	F	E	D	C	B	A

‘We meet at the afternoon’ = ‘Dv nvvg zg gsv zugvimllm’

We decided to invert the abecedary so it doesn’t goes as easy as it seems.

Activity 4: ‘Why is a raven like a writing desk?’ from *Alice in Wonderland*

-both raven and a writing-desk have feathers.

-both appear in death.

-both have to do with literature.

-The raven has an intelligence connotation, same as a desk to write.

10.4.14. Group 14

Activity 1: The crime scene

The dead woman, before dying, tries to write the name of her murderer on the ground with her ring. As she writes the name, the ring wounds her, and that is why there is blood. Unfortunately, she dies before she can finish the name of her murderer, Rachel.

Activity 2: A newspaper enigma

They try to call the attention of the police so that they go to that place where the only thing the police are going to find is their next victim already dead, while they, on the other side of the city, are already preparing their next murder.

Activity 3: Create your own cipher

AVOCADO – BRDFBHD

Advance in the alphabet the number of positions of the letter of the original word, for example, as ‘a’ is the first letter we advance one position and put ‘B’, as ‘c’ is the third letter, we advance three positions and we put the ‘F’ and so on.

Activity 4: ‘Why is a raven like a writing desk?’ from *Alice in Wonderland*

On the desk, imagination flies by writing with a feather and the crow flies thanks to a feather.

The explanation is simple, you can write with a feather on your desk, that is why your imagination flies and the crow needs its feathers to fly.

10.4.15. Group 15

Activity 1: The crime scene

Because ‘rache’ means revenge in German, we can say that the woman was killed for that reason. Because the body is face down, we can assume that she was attacked from behind. And it can be explained that the ring is dirty on the outside as the word ‘rache’ was written with it on the dirty ground.

Activity 2: A newspaper enigma

One possibility is that Betty has kidnapped Augustine. This message is a key to being able to claim Augustine’s ransom from James as they are probably close relatives. Meet James by this means to make it less obvious and the meeting place is the bakery.

Activity 3: Create your own cipher

Each letter of the alphabet has a number assigned to it according to the place it occupies. So A would be 1 or M would be 13. Depending on the type of number previously assigned to each letter, new combinations

are formed. For this purpose, we have divided the types into single-digit even, double-digit even, single-digit odd, double-digit odd, single-digit prime and double-digit prime. Each type corresponds to a number from 1 to 6 according to the order mentioned above, placed consecutively next to the previously assigned number. Thus, A would be 15 or M 136.

Activity 4: ‘Why is a raven like a writing desk?’ from *Alice in Wonderland*

Apparently the crow and the desk have nothing in common. To ask this question is absurd. The crow is an animal, the desk is an inanimate object. The desk is a piece of furniture with a clear function, to serve as a place to work or read, the body has the same function as any other living being. The desk as an artifice or human creation may have a reason for existence but it is always linked to its creator or owner who is the one who uses it. The crow, on the other hand, is faced with the same existential problem that all living beings have, which the animal itself may not even consider.

The only point I see that they may have in common is that the raven in some cosmologies is seen as a bearer of wisdom and the desk is the place where we foster our intellect.

10.4.16. Group 16

Activity 1: The crime scene

A woman has been found dead inside a room in a small hostel. Investigators believe it to be a murder. They believe she has been murdered because of the layout of the body: she is lying face down on the floor. The woman is dressed nicely, which is strange as the hostel where she is staying has a bad reputation and is rather dirty and low class. When investigators investigate the hostel they discover that it is a place where people frequent for extramarital encounters. The clue of the ring would fit perfectly with the assumption that the victim had dated a married man. The ring is dirty on the outside, indicating that it has been used. However, the ring has been cleaned on the inside so as to

erase the dna or any trace that could identify its owner. The letters drawn on the ring are clearly visible, they were the woman's last words. At a guess, the investigators believe that she was most likely trying to write the name 'Rachel', so they search for that name in the woman's mobile phone contacts. They find two different numbers, one was her babysitter and the other her best friend. They call her best friend in for questioning and, unsurprisingly, the friend was aware of the infidelity. She told them that her friend was seeing a man who was also married and they used to meet at that hostel. They went to the man's house and met his wife, who confirmed that the ring belonged to him. The man was arrested and during interrogation, he tearfully confessed to the crime.

Activity 2: A newspaper enigma

James and Betty met in the summer of 1879. James was travelling to North London on business, he was a reputable textile merchant in his home town. An order did not go as it should and he had to go to the mills to talk to the supplier. The factory was located on the outskirts of a small town in the north of London. James took a train into town and there he caught a carriage that promised to take him to the factory. In those days, any trip, no matter how short it seemed, could turn into a long and inconvenient ride. As expected, after several hours on the road, the horses fell exhausted and they had to stop to sleep as it was already dark. They found a small pub that was still open and went in to ask questions. James told his situation to the barmaid, with whom he fell in love at first sight. It turned out that the waitress was a cousin of the owner of the factory James was going to. The next day, Betty the waitress accompanied him to the factory. On the way there, they talked non-stop and the love between the two young people was born. Betty was leaving the following week for Spain to take care of her sick grandmother. Betty and James could not continue their story at that time, but they fell in love so much that they agreed that when Betty returned from Spain she would look for James to finish what they had started. Five years later Betty returned. She wanted to look for him but she didn't know how, or if he would have a wife or children, so she decided to write in that section of the newspaper in the hope that James would read it and they could see each other there.

Activity 3: Create your own cipher

Example: 20 12 4 27 9 23 2 12 6, how are you

A: 27	B: 26	C: 25	D: 24	E: 23
F: 22	G: 21	H: 20	I: 19	J: 18
K: 17	L: 16	M: 15	N: 14	Ñ: 13
O: 12	P: 11	Q: 10	R: 9	S: 8
T: 7	U: 6	V: 5	W: 4	X: 3
Y: 2	Z: 1			

This was the code I used in high school to communicate with my friends in class through secret notes. It wasn't very difficult to guess, at first we were going to put random numbers for each letter but we realised that we wouldn't remember which letter they corresponded to. Every time a teacher caught our notes and opened the paper to see what it said, they were very surprised and, when they saw our ingenuity, they laughed and almost never punished us. It was quite funny until one of us explained the code to one of the boys in class and it was no longer a secret. They all found out and could now decipher our messages.

Activity 4: 'Why is a raven like a writing desk?' from *Alice in Wonderland*

They both have legs and they both have feathers (birds' feathers and writing feathers).

10.4.17. Group 17

Activity 1: The crime scene

The woman that has been found dead is lying in the floor and there's some letters painted, that can be attributed to her writing. There's a ring

that is dirty in the outside but very clean in the inside, so we can think that the ring the ring was worn doing something involving dirt, but we ruled out writing on the ground as it was not something sharp. It is a counter-indicating clue, as the woman is well dressed and this contrasts with her wearing an unusually dirty ring. Perhaps the ring is not hers, but fell off the person who committed the murder. The writing on the floor would be very innocent to think that it was made by the woman in an attempt to prove something about her murder. It's probably made by the murderer in order to mislead the people who will be investigating the case. The woman easily has a family member or friend named Rachel, or at the very least the detectives will investigate whether a friend she had problems with is called Rachel.

Activity 2: A newspaper enigma

In this case, this secret message that has been discovered is theoretically from Betty to James, but in reality what is happening is that two anonymous people are trying to plant a bomb in the town, where there has been some criminal activity before. Agustín might seem that he is a common child of both, but in reality it is the name of the bomb that they are planning to explode in a nearby Church. The meeting point of both is a bakery. This bakery could secretly connect with the Church next to it, so they really plan to attack a Church. Finally, all the names are coded so that if found out, it could look like a family plot.

Activity 3: Create your own cipher

In our example of our cryptic circle, the team has think that it would be harder to decipher if we add an extra circle inside the circle given in the powerpoint, so, what we are going to do is adding a interior extra circle mooving the letter of the medium circle one time, i mean: If A is D, adding our circle, D will turn on C. So, by analogy, A is C.

A is D, D is C.	S is V, V is U.	N is O, O is P.

Cup cripted will be ASN.

Activity 4: ‘Why is a raven like a writing desk?’ from *Alice in Wonderland*

Beyond physical similarities such as the fact that both are supported by legs, we can say that both a raven and a desk witness a death. They are left with the remains: the desk, with the last words, and the raven with what is left of a matter. In the case of the desk we don’t need to understand death so literally, and it may simply be a metaphor for something that ends, and the story we tell of it. Or a story that hasn’t happened like that but we want to make it up, then we would be touching on the idea of carrion, familiar to crows. It is another similarity: crows are intelligent animals, and it is at the desk that we often deploy our intellect. Finally, we could say that there is a romanticisation around both of these things. At first we would think of the raven as a solitary animal, because it suits us best with the myth of the tormented; the same goes for the writer. Both the raven and the writer can be happy, even if it doesn’t suit our narrative.

10.4.18. Group 18

Activity 1: The crime scene

We have a woman in pink lying dead on the floor who seems to have written ‘rache’ with her nails on the floor, a word that means ‘revenge’ in German. At the same time, we know that the victim has a marriage ring on her finger which is clean on the inside and dirty on its outside. Based on the evidence we have, we can think that we are in front of a passionate crime. Maybe the marriage was not at its best moment and the woman was having an affair. The husband, unable to bear the idea of his wife having a lover, decided to go after her and kill her. In her last moments and using her remaining strength, the woman wrote that word on the ground to help detectives find her murderer and bring her justice.

Activity 2: A newspaper enigma

We have a woman called Betty who is writing in a local newspaper a subliminal message to a man called James, who seems to be her secret

lover. She is telling him to meet her because her husband, Augustine, is well again. It turns out that the couple's plan was to poison the young woman's rich husband to his death, as this was the only way to break their marriage of convenience. But the ship with which they had to flee after seizing the inherited fortune sets sail soon and Augustine, instead of getting worse, seems to recover from his poisoning.

Activity 3: Create your own cipher

A	B	C	D	E	F	G	H	I	J	K	L	M
Z	Y	X	W	V	U	T	S	R	Q	P	O	N

N	O	P	Q	R	S	T	U	V	W	X	Y	Z
M	L	K	J	I	H	G	F	E	D	C	B	A

Substitution of one letter by its contrary. For example, A is substituted by Z, so APPLE in the cipher will become ZKKOV.

Activity 4: 'Why is a raven like a writing desk?' from *Alice in Wonderland*

Both, the raven and the desk can fly: the first one with its wings and the second one throw the imagination of the one who sits down to write. Moreover, the two of them have almost one feather: the first one to cover its body and the second one to write.

10.4.19. Group 19

Activity 1: The crime scene

On the one hand, at the crime scene we can see a ring that is dirty on the outside and clean on the inside, in such a way that we can suspect that the victim took it off and kept it so that no one would see it.

On the other hand, the word written on the ground means 'revenge' for the German, so I would bet that the murderer is her German husband in a fit of rage when he realized that his wife was cheating on him.

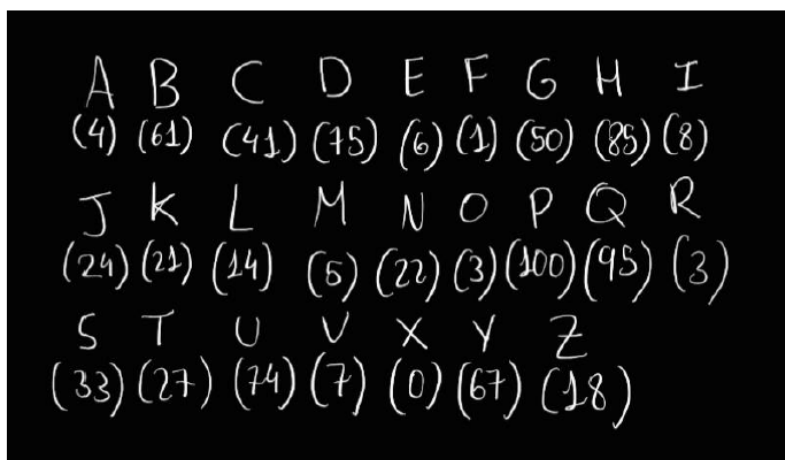
Activity 2: A newspaper enigma

Behind this secret message in the local newspaper is a drug trafficking network. James, the addressee of the message, is the dealer in charge of distributing the drug directly to the consumers, on the other hand, Betty is the person in charge of taking the drug from the point where it is manufactured to the final sellers, the message that Augustine is well refers to the fact that the drug is ready, and finally Macclesfield road in Holmes Chapel is the area where they will have to meet to make the exchange.

Activity 3: Create your own cipher

This message is encrypted using a numerical code, in order to decipher this message you will need to use an encrypted alphabet that is attached.

Message: 14-3-22-50 / 14-8-7-6 / 5-4-3-0



A	B	C	D	E	F	G	H	I
(4)	(61)	(41)	(15)	(6)	(1)	(50)	(85)	(8)
J	K	L	M	N	O	P	Q	R
(24)	(21)	(14)	(5)	(22)	(3)	(100)	(95)	(3)
S	T	U	V	X	Y	Z		
(33)	(27)	(74)	(7)	(0)	(67)	(18)		

Activity 4: ‘Why is a raven like a writing desk?’ from *Alice in Wonderland*

To the question of what a crow and a desk have in common, there seems to be no clear answer. If we look superficially both the crow and the desk seem to have nothing in common, one is something we find in nature and has life, the other however is a socially produced product as well as

being lifeless.

But to answer this question we could go back to the time when Democritus was alive and ask him about what a raven and a desk have in common, to which (without knowing if he could find an answer from the surface) he would probably answer that both are composed of atoms and emptiness, so following the line of the pre-Socratic philosopher we will answer that what a raven and a desk have in common is that both are composed of atoms and emptiness.

10.4.20. Group 20

Activity 1: The crime scene

Angela and David had a healthy relationship. One day David proposed to her, but he gave her the ring of his grandmother Rache who was in coma. The next day, the grandmother woke up from the comma and killed Angela.

Activity 2: A newspaper enigma

Betty and James are udner suspicion and guarded secretly. They can't call each other or meet easily, so Betty writes this short messages for talk about the crime.

Activity 3: Create your own cipher

A	B	C	D	E	F	G	H	I	J	K	L	M
12	13	14	15	16	17	18	19	20	21	22	23	24

N	O	P	Q	R	S	T	U	V	W	X	Y	Z
25	26	27	28	29	30	31	32	33	34	35	36	37

We chose to make the code with numbers.

Activity 4: “Why is a raven like a writing desk?” from *Alice in Wonderland*

The raven rest on the wood of the trees and the writing desk is made by the same wood.

10.5. Pictures from the classroom teaching experience



10.6. Anonymous survey template

THIS EVALUATION IS **ANONYMOUS**,
PLEASE **DO NOT** WRITE YOUR NAME.

SOLVING MYSTERIES: A PRACTICAL APPLICATION OF LOGICS

Student post evaluation

On a scale from 1 to 5, 1 being strongly disagree and 5 being strongly agree, please answer the following questions:

En una escala del 1 al 5, 1 siendo completamente en desacuerdo y 5 completamente de acuerdo, por favor responde a las siguientes preguntas:

1. **Organisation**/Organización

En una escala del 1 al 5, 1 siendo completamente en desacuerdo y 5 completamente de acuerdo, por favor responde a las siguientes preguntas:

	1	2	3	4	5
The activities followed a logical structure. Las actividades estaban organizadas de forma lógica					
The goals were defined clearly. Los objetivos de la actividad se definieron claramente					
The right amount of time was spent on each activity. Se empleó el tiempo necesario para cada actividad.					
The class was dynamic. La clase fue dinámica.					
The level of difficulty was adequate. El nivel de dificultad fue el adecuado.					

2. Contents/Contenido

	1	2	3	4	5
The activities followed a logical structure. Las actividades estaban organizadas de forma lógica					
The goals were defined clearly. Los objetivos de la actividad se definieron claramente					
The right amount of time was spent on each activity. Se empleó el tiempo necesario para cada actividad.					
The class was dynamic. La clase fue dinámica.					
The level of difficulty was adequate. El nivel de dificultad fue el adecuado.					

3. The students and the teacher/Los estudiantes y la profesora

	1	2	3	4	5
I felt comfortable during the class. Me sentí cómodo/a/e durante la clase.					
The teacher explained the activities clearly. La profesora explicó las actividades con claridad.					
The activities encouraged teamwork. Las actividades motivaron el trabajo en equipo.					
The teacher was approachable and willing to help. La profesora se mostraba accesible y dispuesta a ayudar.					
Overall, I enjoyed the class. En general, me gustó la clase.					

4. The activities/Las actividades

On a scale from 1 to 5, 1 being not interesting at all and 5 being extremely interesting, please give your opinion about the following activities:

En una escala del 1 al 5, 1 siendo nada interesante y 5 extremadamente interesante, por favor da tu opinión sobre las siguientes actividades:

	1	2	3	4	5
Activity 1: A crime scene from Sherlock Holmes Actividad 1: Una escena del crimen de Sherlock Holmes					
Activity 2: A suspicious message on the newspaper Actividad 2: Un mensaje sospechoso en el periódico					
Activity 3: Create your own cipher. Actividad 3: Crea tu propio cifrado					
Activity 4: Solve a riddle from <i>Alice in Wonderland</i> Actividad 4: Resuelve un acertijo de <i>Alicia en el País de las Maravillas</i>					

5. Any last words? / Últimas palabras

Lastly, please write whether there were things that you found positive, that could be improved or any other remark or suggestion you might have (if any):

Por último, por favor escribe si hay cosas que te parecieron positivas, que se podrían mejorar o cualquier otro comentario o sugerencia (si las tienes):

10.7. Survey results

10.7.1. Organisation

	Logical structure		Defined goals	
1	0	0%	0	0%
2	3	6%	0	0%
3	5	11%	5	10%
4	12	26%	12	25%
5	27	57%	31	65%
Average	47	4.34	48	4.54

	Time		Dynamism		Level of difficulty	
1	0	0%	1	2%	0	0%
2	5	10%	1	2%	0	0%
3	15	31%	1	2%	4	9%
4	12	25%	10	21%	15	32%
5	16	33%	35	73%	28	60%
Avg	48	3.8	48	4.6	47	4.51

10.7.2. Contents

	Different ways		Interest		Learnt something new	
1	1	2%	0	0%	3	6%
2	1	2%	2	4%	3	6%
3	13	27%	2	4%	14	29%
4	11	23%	13	27%	12	25%
5	22	46%	31	65%	16	33%
Avg	48	4.08	48	4.52	48	3.73

	Problem-solving skills		Critical thinking skills		Usefulness	
1	2	4%	4	8%	6	13%
2	5	10%	4	8%	5	10%
3	7	15%	8	17%	11	23%
4	11	23%	17	35%	11	23%
5	23	48%	15	31%	15	31%
Avg	48	4	48	3.73	48	3.5

10.7.3. The students and the teacher

	Felt comfortable		Clear explanation	
1	0	0%	0	0%
2	3	6%	0	0%
3	2	4%	1	2%
4	3	6%	10	21%
5	40	83%	37	77%
Average	48	4.67	48	4.75

	Teamwork		Helpful teacher		I enjoyed the class	
1	0	0%	0	0%	0	0%
2	2	4%	1	2%	3	6%
3	1	2%	2	4%	3	6%
4	8	17%	3	6%	8	17%
5	37	77%	42	88%	34	71%
Avg	48	4.67	48	4.79	48	4.52

10.7.4. Activities

	Crime scene		Suspicious message	
1	1	2%	0	0%
2	1	2%	2	4%
3	8	17%	3	6%
4	18	38%	22	46%
5	20	42%	21	44%
Average	48	4.15	48	3.92

	Cipher		Riddle	
1	1	2%	1	2%
2	7	15%	1	2%
3	7	15%	7	15%
4	13	27%	9	19%
5	20	42%	30	63%
Average	48	3.92	48	4.38

The total average was 4.3.

