

Alan Turing:

Thinking the Unthinkable, Solving the Unsolvable

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Junior Division

Group Exhibit

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## PROCESS PAPER

(Caleb's POV) Departing the airport late one night, my mother called an UBER to get home. After an eternity, everyone hopped in a rugged car, exhausted. Still awake, I was fascinated by the operations of UBER and other ridesharing apps. Eager, I researched on my computer once we arrived home. Apparently, "artificial intelligence" was involved, and after further investigation, I realized AI was also integrated in plagiarism checkers, mobile check deposits, spam filters, and much more. Later, when my team and I were introduced to NHD, we discussed with our teacher the topic of people who had broken barriers through AI. After more in-depth research, we decided to describe the life of Alan Turing and his contributions.

Our project, "Alan Turing: Thinking the Unthinkable, Solving the Unsolvable" details Turing's contributions to World War II and the significance of his breakthroughs in computer science. We conducted research through databases, Google search terms, source references, and country codes. Since Turing's nationality was British, we found many of our best sources from the UK web by using its country code, +44, as well as looking for sites with .uk at the end, to view primary source documents of Turing's contributions from Britain itself.

We incorporated many symbolic parts of Turing's life into our exhibit, one such aspect being the British flag, which we used to portray Turing's nationality. Another method of symbolizing Turing's life was creating a title with the background of WWII newspaper articles to symbolize the battles that were fought over the course of his life and the cause of arguably the most important invention and breakthroughs in his career, the Bombe machine, which deciphered the ENIGMA code. Speaking of which, we created a miniature replica of the Bombe machine to once again emphasize how important the Bombe was in the outcome of WWII, as well as Turing's major contribution to computer science. We also included a puzzle book to represent the "ENIGMA" of

codes and challenges Turing overcame when breaking ENIGMA. Finally, we added a typewriter to our exhibit to symbolize the technology of Turing's era, as back then typewriters were the standard form of communication.

Our topic relates to the annual theme because Turing overcame several barriers that many before him failed to accomplish. His technological achievements revolutionized the history of modern computing and have influenced many of the electronic devices that we use today, including our computers, smart phones, and digital assistants, to name a few. Turing's idea of machines performing human tasks more efficiently has become more of a reality in recent years as we enter the technology age in a world dominated by AI software, robots and other machines that greatly assist us in our labors. Without Turing's contributions in breaking those barriers, our civilization wouldn't be as developed and not as much progress would've been made because of the lack of technology to help our industries. The technological barriers Turing broke have significantly influenced history and impacted the way our world's computer programs run.

## Annotated Bibliography

### Primary Sources

“A Chassis from the Pilot ACE, One of Many That Made up the Memory Bank of the Entire Computer.” Digital image. *National Physical Library*, NPL. Accessed 15 Nov. 2019.

This primary image shows the significance of the Pilot ACE, as it was one of the first computers that were built in the United Kingdom at the National Physical Laboratory, designed by Alan Turing. This shows that Turing’s anachronistic ambitions impacted his works and the effect of other machines such as Enigma and tunny during World War II.

Babbage, Charles. *Passages from the Life of a Philosopher*. United Kingdom, Longman, Green, Longman, Roberts, & Green, 1864. Accessed 2 Dec. 2019.  
[https://books.googleusercontent.com/books/content?req=AKW5Qacfn4fiBB05PaN65mGC\\_ok6Q2bmqp1kuHpUmCoWQvPmAeJx-z9H8ADscE4RdGHwXPJYVMgPYs-yd-e8oNhibCU3oYU-OfgdeckdU-9ne9FPmT-8idhyJ9bVL3-KulyCra29WD2RuQ-iaFUNfU0SOFZdwD9NK9RgzesLcgovgwwJrcoESYUwGAUzN4e2hovCZ5zGhYdXDWAKwO11d6SK775R3m5NfoMr3UTHb8AXq5GB6hCLPQ3fVOaSg\\_KKEYOdakkMxLqmYMrbqV2\\_J3c2b9BY2UrGxw](https://books.googleusercontent.com/books/content?req=AKW5Qacfn4fiBB05PaN65mGC_ok6Q2bmqp1kuHpUmCoWQvPmAeJx-z9H8ADscE4RdGHwXPJYVMgPYs-yd-e8oNhibCU3oYU-OfgdeckdU-9ne9FPmT-8idhyJ9bVL3-KulyCra29WD2RuQ-iaFUNfU0SOFZdwD9NK9RgzesLcgovgwwJrcoESYUwGAUzN4e2hovCZ5zGhYdXDWAKwO11d6SK775R3m5NfoMr3UTHb8AXq5GB6hCLPQ3fVOaSg_KKEYOdakkMxLqmYMrbqV2_J3c2b9BY2UrGxw).

This autobiography highlights the “technological genius who invented the first computer a hundred and fifty years ago.” It also talks about “his unpublished designs of machines he had created including the Difference Engine and the Analytical Engine. His designs paved the way for the Computer Revolution, and his philosophies helped Konrad Zuse, Ada Lovelace, and Alan Turing invent machines which would also make huge contributions to modern computing. We used this source for more-informed analysis in context, talking about how the Analytical Engine was the basis of some of Turing’s designs, including Bombe and ACE.

“Battle of Atlantic.” Digital image. *Pacific War*. Accessed 1 Dec. 2019.  
[http://www.pacificwar.org.au/webgraphics/Atlantic/800px-Atlantic\\_Merchant\\_Casualty.JPEG](http://www.pacificwar.org.au/webgraphics/Atlantic/800px-Atlantic_Merchant_Casualty.JPEG).

This photograph shows some of the merchant ships which were sunk by German U-Boats in the Battle of the Atlantic during World War II. The photograph can represent historical context during World War II, as the Battle of the Atlantic was one of the biggest battles fought on sea, turning the tide of the war during World War II.

Borchert, Erich. "German General Heinz Guderian in a SdKfz. 251/3 Halftrack Vehicle, France, May 1940, Note Early 3-Rotor Enigma Machine." *World War II Database*, 4 Dec. 2009. Accessed 12 Dec. 2019. [https://ww2db.com/image.php?image\\_id=9076](https://ww2db.com/image.php?image_id=9076).

This primary image shows a German encryption crew with an early Enigma machine. This gave us lots of contextual value during World War II, as it showed the process of encrypting a message to send to an ally. This image helped us understand how important encryption was in World War II, as one flaw in the decryption machine would cause serious setbacks.

Boughey, C.L.F. "Summer Term 1928." School Report. Accessed 29 Nov. 2019.

This school report of Alan Turing showed very useful to our research, because it helped us see how unorganized his thought process was, which hurt the recognition of his intelligence, causing distrust from many of his colleagues at Bletchley Park. We used this to add deeper analysis in the build-up and heart of the story, talking about his multiple attempts at cracking Enigma, and conflicts with colleagues.

Bruckner, William Joseph, Benario, Janice Margaret, 1923. Retrieved from the Digital Public Library of America. Accessed 13 Nov. 2019. <http://album.atlantahistorycenter.com/cdm/ref/collection/VHPohr/id/333>.

World War II Veteran Janice Benario recalls her experience as a cryptographer for the US Navy WAVES. This interview gave us a better understanding of the condition of the world at the time and the high stakes, as well as the process of encrypting code. We used this interview to talk about how others who worked at Bletchley Park made huge contributions to not only World War II, but also modern computing today, and how "everyone who taps a keyboard has used Turing's and other impactful computer engineers' philosophies."

Burnley, Ray. "A Late Design for an Analytical Engine." Digital image. *The Babbage Pages*. The Babbage Pages, 8 Jan. 1997. Accessed 1 Dec. 2019.

This primary image shows the significance of the Analytical Engine, as it was a "proposed mechanical general-purpose computer designed by Charles Babbage." His machine influenced several future computer scientists such as Alan Turing, Torres y Quevedo, and Vannevar Bush, who wrote papers and essays referring to his design, and how other electromagnetic machines could further be scrutinized.

“Charles Babbage.” *Computer History*. Accessed 17 Mar. 2020. [history-computer.com/Babbage/Babbage.html](http://history-computer.com/Babbage/Babbage.html).

This primary source image of Charles Babbage helped represent how Babbage started working on designs for what would become the first computer. Turing later went on to improve and complete Babbage’s designs, revolutionizing the field of technology.

Copeland, Brian Jack, and Diane Proudfoot. “Alan Turing: Father of the Modern Computer.” *Rutherford Journal*. Accessed 10 Nov. 2019. [www.rutherfordjournal.org/article040101.html](http://www.rutherfordjournal.org/article040101.html).

The primary source images within this website gave us a very thorough understanding and summary of our topic. We used this information and pictures throughout our project and was also used during our research phase, creating more-informed analyses on all five sections of the write-up.

“German U-Boat.” Digital Image. *Uboat*. Accessed 10 Dec. 2019. <http://uboat.net/media/boats/photos/u48.jpg>.

This is a picture of a German U-boat. These U-boats were especially deadly in WWII, notably at the Battle of Atlantic, where German forces fought the Allies overseas.

Gladwin, Lee A, and Hodges, Andrew. “Visit to National Cash Register Corporation of Dayton, Ohio.” Dayton, Ohio: Feb. 1942. Accessed 26 Nov. 2019. <https://www.turing.org.uk/sources/dayton123.html>.

This primary source report showed Turing monitoring the production of his own machine from the USA. This gave us a better understanding of his thoughts on his own machine which benefited multiple parts of our project.

Howard, Emily. “Ada Lovelace.” *The Guardian*, 2 Nov. 2019. Accessed 15 Feb. 2020. <https://www.theguardian.com/music/2019/nov/02/ada-lovelace-emily-howard-composer>.

This picture of Ada Lovelace gave us a better understanding of how Lovelace and Charles Babbage collaborated to create the initial designs for a working computer, which Turing later went on to tweak and finish.

Mowry, David P. "Assembling the Rotor Set." *National Security Agency*, National Security Agency, 2014. Accessed 15 Dec. 2019.  
[www.nsa.gov/Portals/70/documents/about/cryptologic-heritage/historical-figures-publications/publications/wwii/german\\_cipher.pdf](http://www.nsa.gov/Portals/70/documents/about/cryptologic-heritage/historical-figures-publications/publications/wwii/german_cipher.pdf).

This primary source image was a diagram detailing the inner workings of the ENIGMA machine and how its rotors and spinning wheels could change to make millions of possible combinations for the code. We used this information for our context part of the project to demonstrate how the ENIGMA machine worked and why the Germans used this code for its extreme complexity.

Mowry, David P. "PDF." National Security Agency, 2014. Accessed 15 Dec. 2019.  
[https://www.nsa.gov/Portals/70/documents/about/cryptologic-heritage/historical-figures-publications/publications/wwii/german\\_cipher.pdf](https://www.nsa.gov/Portals/70/documents/about/cryptologic-heritage/historical-figures-publications/publications/wwii/german_cipher.pdf).

This source has various primary pictures of how several code machines function, like the Enigma. This gives us a better understanding of the magnitude of difficulty it was to break the Enigma code and how Turing figured out how to create the Bombe to counter Enigma messages.

Neuman, John von. Received by Alan Turing, Cambridge University, 1 June 1937, Cambridge, England. Accessed 14 Nov. 2019.

This letter written by John von Newman shows the faith of a man who wants to see the capabilities of Alan Turing, asking him to transfer from Cambridge University to Princeton University. This letter has helped us uncover some of Turing's complicated past and shows that there were people who believed Turing would one day do great things.

PrayerFilms, Windanda, director. "Interview with Bletchley Park Codebreaker Hazel Gregory." *YouTube*, YouTube, 27 Dec. 2014. Accessed 6 Dec. 2019.  
[www.youtube.com/watch?v=hVY\\_PpzyY\\_o](http://www.youtube.com/watch?v=hVY_PpzyY_o).

This is an interview of former Bletchley Park Codebreaker Hazel Gregory. This gave us a much better understanding of the life of being a codebreaker, and all the hard work and logical thinking put required for decrypting codes.

“The German Enigma Machine.” *British National Archives*. Accessed 29 Nov. 2019.  
<http://www.nationalarchives.gov.uk/education/worldwar2/theatres-of-war/atlantic/investigation/battle-of-the-atlantic/sources/photo/2/>.

This image gave us a visual representation of the ENIGMA machine, how it functioned, and an idea of what obstacles the Bletchley Park codebreakers faced when deciphering the German code.

Turing, Alan M. Computing Machinery and Technology. *Mind* 49: 433-460, 1950, pp. 1–22, Computing Machinery and Technology.

This report made by Alan Turing was considered one of his greatest publications of all time. We used this report to better comprehend Turing’s ideas and the explanations of his thinking in intelligent machines.

Turing, Alan M. Ph. D. “Report on Cryptographic Machinery Available At Navy Department Washington.” Washington D.C.: 28 Nov. 1942. Accessed 10 Dec. 2019.  
<http://www.turing.org.uk/sources/washington.html>.

This report by Turing himself shows his reaction to the cryptologic machinery developed in the US available for use. We used this source for his answer about the machinery and the technical and mechanical descriptions of the machinery.

## Secondary Sources

“Alan Mathison Turing.” *Bio*. A&E Television Networks, 2014. Accessed 20 Nov. 2019.  
<https://www.biography.com/scientist/alan-turing>.

This biography included in-depth information on cryptanalysis and early computers that had previously been invented by other famous figures such as Charles Babbage and Ada Lovelace. It also talked about Turing’s conviction and death after he identified as homosexual. We used this source for context, talking about how machines functioned, such as the Analytical Engine, and how it compared to future machines involving artificial intelligence based off Turing’s philosophies.

“Alan Turing’s Legacy.” *The New York Times*, The New York Times, 23 June 2012. Accessed 1 Dec. 2019. [www.nytimes.com/2012/06/23/opinion/alan-turings-legacy.html](http://www.nytimes.com/2012/06/23/opinion/alan-turings-legacy.html).

This source gives a civilian's perspective of Alan Turing's impact 65 years after his death, focusing on the unfair treatment that was given to him for being homosexual. We used this source for the information of his scientific achievements, despite his gross indecency accusation overshadowing his legacy.

"Alan Turing." *The British Library*, The British Library, 15 Jan. 2014. Accessed 31 Oct. 2019. <https://www.bl.uk/people/alan-turing>.

This secondary source answered questions about the basics of Turing's life in a detailed but concise way. We used this source as part of the foundations to understanding Turing and his life's works and actions.

"Alan Turing: Creator of Modern Computing." BBC Teach, BBC, 27 Aug. 2019, [www.bbc.co.uk/teach/alan-turing-creator-of-modern-computing/zhwp7nb](http://www.bbc.co.uk/teach/alan-turing-creator-of-modern-computing/zhwp7nb).

This website presented a timeline that included key events during Alan Turing's life, and the effects those events had on the gifted mathematician. This source allowed us to get a better understanding of what the most significant parts of Turing's life were.

Brilliant Maps Editors. "What If Nazi Germany Won World War II? Fictional & Historical Scenarios." Brilliant Maps, 19 Jan. 2015. Accessed 19 Dec. 2019. [brilliantmaps.com/what-if-nazi-germany-won-world-war-ii/](http://brilliantmaps.com/what-if-nazi-germany-won-world-war-ii/).

This source analyzed Germany's strategy in WWII and found its flaws, while also suggesting scenarios if the Germans had won crucial battles or decisions. We used this source mainly for our long-term impact to determine how the world would be like without the impacts of Turing and his works with Bletchley Park.

Budiansky, Stephen. *Battle of Wits: The Complete Story of Codebreaking in World War II*. New York: Free, 2000. Accessed 17 Nov. 2019.

This book was essential in giving us deep insight and information into different sections of codebreaking during the duration of World War II. It explained Alan Turing's importance during the war and provided extensive facts about Bletchley Park and their works. We used this information in our context to talk about Bletchley Park and how their secrecy allowed for more extensive work.

Carpenter, B.E. "PDF." CERN, 1972. Accessed 29 Nov. 2019.  
<https://cds.cern.ch/record/263304/files/p230.pdf>.

This source gave an analysis of one of Turing's works created after the war, known as ACE, or the first complete design for a stored-program electronic computer ever. We used this source to understand what Turing's fate was after the war was over and what he did once he was done with being a codebreaker.

Carver, Michael. "COMPUTING THE ENIGMA OF ALAN TURING." *Contemporary Review*, vol. 289, no. 1685, Summer, 2007, pp. 246-247. *elibrary*. Accessed 31 Oct. 2019.  
<http://ezproxy.kcls.org/login?url=https://explore.proquest.com/elibrary/document/204959678?accountid=46>.

This source gave a brief history on Alan Turing's work for the British and his contributions to WWII and decrypting German ENIGMA codes. This article gave us an even further understanding of just how influential Turing's work was not just to winning the war for the Allies but also as a new basis for modern computing.

Copeland, Brian Jack. "Alan Turing." *Britannica Library*, Britannica, 2019. Accessed 1 Nov. 2019.  
<https://library-eb-com.ezproxy.kcls.org/levels/youngadults/article/Alan-Turing/73839>.

This secondary source provided us with insight with his inspirations for the Bombe and his beliefs of machines being able to think like humans. We incorporated this source into our research of his works with the Bombe machine, as well as the build-up and heart of story.

Copeland, Brian Jack, and P. "Alan Turing: Codebreaker and Computer Pioneer." *History Today*, 2004, pp. 7. *History Study Center*. Accessed 30 Oct. 2019.  
[http://gateway.proquest.com/openurl?url\\_ver=Z39.88-2004&res\\_dat=xri:ho-us&rft\\_dat=xri:ho:sup\\_pq\\_pdf:665706831:665706831::PAGE:28211:28211](http://gateway.proquest.com/openurl?url_ver=Z39.88-2004&res_dat=xri:ho-us&rft_dat=xri:ho:sup_pq_pdf:665706831:665706831::PAGE:28211:28211).

This source recalls the contributions of Alan Turing to World War II from 1939-1945 while working at Bletchley Park as a codebreaker. It talks about Turing's dream of philosophizing computers, mainly "controlling a computer's operations by means of a program of coded instructions stored in memory" and his major significance in the Allied victory. We used this source to provide more-informed analysis in Turing's Intellectual Machinery, showing how he broke barriers through computing and AI.

Copeland, Brian Jack. "Alan Turing." *Encyclopedia Britannica*, Encyclopedia Britannica, Inc., 20 July 1998. Accessed 4 Nov. 2019. [www.britannica.com/biography/Alan-Turing#ref214877](http://www.britannica.com/biography/Alan-Turing#ref214877).

This article explained through description Alan Turing's life, including his childhood and his works while he was at Bletchley Park. It also described his accomplishments and how his machines helped shape some machines that are used today. We used this article to write more informed analysis for our heart of the story and long-term impact.

Copeland, Brian Jack. "Catalogue: WW2 Codebreaking." *AlanTuring.net*. 1999. Accessed 29 Nov. 2019. [http://www.alanturing.net/turing\\_archive/archive/index/codebreakingindex.html](http://www.alanturing.net/turing_archive/archive/index/codebreakingindex.html).

This secondary source, an Alan Turing internet scrapbook and his relations to the Enigma and the Tunny machine, which were machines he and his colleagues designed and used to benefit Germany during World War II. We used this source to find relationships between Turing and the Enigma and with Tunny.

Copeland, Brian Jack. "The Essential Turing: Seminal Writings in Computing, Logic, Philosophy, Artificial Intelligence, and Artificial Life: Plus The Secrets of Enigma." Oxford: Clarendon, 2004. Accessed 20 Nov. 2019.

This book written by Brian Jack Copeland provides a comprehensive study of Turing's major effects on today's modern technology era by retracing the steps back to his creations and theorizations of machines performing human tasks. We used his book while researching our topic and used the content of the book throughout our project to prove Turing's preeminent impact on our world today.

Copeland, Brian Jack. "The Modern History of Computing." *The Stanford Encyclopedia of Philosophy* (Winter 2017 Edition), Edward N. Zalta (ed). Accessed 5 Dec. 2019. <https://plato.stanford.edu/archives/win2017/entries/computing-history/>.

This encyclopedia entry touched on machines which have shaped the history of modern computing, either electronic or digital. This contributes towards proving our thesis of the huge influence that Turing had on the world.

Davidson, Amy. "Alan Turing's Apple – The New Yorker." *The New Yorker*. The New Yorker, 10 Aug. 2011. Accessed 2 Nov. 2019. <http://www.newyorker.com/news/amy-davidson/alan-turings-apple>.

This newspaper article was very beneficial to our research, as it explained Turing's death, the Turing Test, and Alan Turing's legacy on how it affects us in the modern day. We incorporated this into our research, as we added descriptive information on machines Turing created, and we analyzed information from other sources that we included in both short-term and long-term impacts.

Daylight, Edgar G. "A Turning Tale." *A Turning Tale*, 1 Oct. 2014. Accessed 18 Nov. 2019. <http://cacm.acm.org/magazines/2014/10/178787-a-turning-tale/fulltext>.

This article provided information on Turing's work with the ACE machine, which was another influential creation during World War II. The resource compared many other mathematicians and cryptanalysts' works to Turing. We used this information to show how his work has influenced us.

Eldridge, Golda. "Alan Turing: The Enigma." 2015. Accessed 3 Nov. 2019. <https://explore-proquest-com.ezproxy.kcls.org/elibrary/document/1756226248?searchid=1572811438&accountid=46>.

This database source gave a fascinating view on Andrew Hodges' book *Alan Turing: The Enigma*, which would later be the foundation for the movie *The Imitation Game*. It also gives a background on Turing's vital contributions to Allies' victory during World War II, and how modern computing wouldn't be the same without his significant works. We used this source during impacts, talking about how ENIGMA was an impactful machine that was the best encryption device which had ever been created.

"Epson HX-20." *Centre of Computing History*, Heritage Lottery. Accessed 3 Apr. 2020. [www.computinghistory.org.uk/det/7038/Epson-HC-20-\(HX-21-UA\)/Heritage](http://www.computinghistory.org.uk/det/7038/Epson-HC-20-(HX-21-UA)/Heritage).

The Epson HX-20 is one of the world's first laptops, released in 1982 and influenced by Turing's theories. We used this image in our timeline to illustrate the distance that Turing's ideas have brought us to today.

“Exhibitions & Learning Online - Exhibitions & Treasures - Secrets & Spies.” *The National Archives*. 13 Nov. 2019. [www.nationalarchives.gov.uk/spies/ciphers/enigma/en1.htm](http://www.nationalarchives.gov.uk/spies/ciphers/enigma/en1.htm).

This source mentions the ENIGMA code’s fatal flaw was that a letter would never be the same letter after encrypted, which was a lead that cryptanalysts like Turing took advantage of and used this information to break the ENIGMA. We used this source in our build-up to show that although some tasks may seem insoluble, there is always a weak link somewhere in the system.

Gladwin, Lee A. “PDF.” National Archives, 1997. Accessed 3 Dec. 2019. [www.archives.gov/files/publications/prologue/1997/fall/turing.pdf](http://www.archives.gov/files/publications/prologue/1997/fall/turing.pdf).

This secondary source gave us a background of how the Bombe and ENIGMA machines functioned. It also talked about how Alan Turing and several other computer mathematicians had the idea of universal machines performing human thinking and tasks.

Haigh, Thomas. “Actually, Turing Did Not Invent the Computer.” ACM, Communications of the ACM, 1 Jan. 2014, Accessed April 10, 2020. [cacm.acm.org/magazines/2014/1/170862-actually-turing-did-not-invent-the-computer/fulltext?mobile=false](http://cacm.acm.org/magazines/2014/1/170862-actually-turing-did-not-invent-the-computer/fulltext?mobile=false).

This website gave us a photo of the EDVAC computer with its creator, John Von Neuman. This helped our project because on our timeline it represented a significant role in technological history as it used binary code instead of decimals, which is the coding program we primarily use today.

Hills, Suzannah. “Alan Turing’s Universal Machine is Named Greatest British Innovation of the 20<sup>th</sup> Century.” *The Daily Mail*, 26 Mar. 2013. Accessed 15 Dec. 2019. <http://www.dailymail.co.uk/sciencetech/article-2299245/Alan-Turings-Universal-Machine-named-greatest-British-innovation-20th-Century.html>.

This source shows the British giving their attention and acknowledgements to Alan Turing, a forgotten hero of the Second World War and the father of modern computing. We used this source to prove our thesis and to show the impact that Turing had caused from his thoughts of machinery thinking and acting like humans, which paid off and helped secure an Allies victory.

Hodges, Andrew. “ALAN TURING INTERNET SCRAPBOOK.” *Alan Turing: The Enigma*, Sept. 1995. Accessed 9 Nov. 2019. [www.turing.org.uk/scrapbook/](http://www.turing.org.uk/scrapbook/).

This source, found on the Alan Turing biography website, is an internet scrapbook that summarizes Alan Turing's entire life and his works that made him notable. We used this scrapbook for various pictures and to also provide some information that we used throughout our entire project.

Hodges, Andrew. "Alan Turing: The Enigma: The Book That Inspired the Film 'The Imitation Game.'" Vintage Books, 2014. Accessed 31 Oct. 2019.

This biography about Alan Turing provided a comprehensive analysis of Turing's entire life, with many exclusive pieces of information and primary sources. We used this biography throughout our entire project and research process and the information given was used to guide us in the correct direction.

Hodges, Andrew. "Alan Turing: The Enigma." *Alan Turing: The Enigma*, Oxford Web Applications, 1995. Accessed 1 Nov. 2019. <https://www.turing.org.uk/>.

This website extension of a biography about Turing provides extensive research and extra information and sources that are not already provided in the biography. This source was our guiding source that we followed and used throughout our entire project and research process.

"Home." *National Physical Laboratory*, NPL, 2019. Accessed 6 Mar. 2020. [www.npl.co.uk/](http://www.npl.co.uk/).

This website was about technology and computer science, and Turing once worked at the NPL during his career. We used this website to understand how Turing's works influenced computer science.

"Impact on World War Two: Air." *Bletchley Park*. Accessed 4 Nov. 2019. <https://bletchleypark.org.uk/our-story/impact-on-world-war-two/air>.

This secondary source depicted the impacts of Bletchley Park and Alan Turing's works in air during World War II. This helped us better understand how Turing's contributions helped the Allies everywhere., such as being able to read huge numbers of enemy messages.

"Impact on World War Two: Land." *Bletchley Park*. Accessed 4 Nov. 2019.  
<https://bletchleypark.org.uk/our-story/impact-on-world-war-two/land>.

This secondary source explained the impacts of Bletchley Park and Alan Turing's works on land during World War II.

"Impact on World War Two: Sea." *Bletchley Park*. Accessed 4 Nov. 2019.  
<https://bletchleypark.org.uk/our-story/impact-on-world-war-two/sea>.

This secondary source illustrated the impacts of Bletchley Park and Alan Turing's works on sea during World War II. This helped us better understand how Turing's contributions helped the Allies everywhere.

Kahn, David. "How Allies Suppressed the Second Greatest Secret of World War II." *History Study Center*, ProQuest, Oct. 2010. Accessed 1 Nov. 2019.  
<http://www.historystudycenter.com/search/proxyProquestPDF.do;jsessionid=7F5F82CB D312569627EAF91991C1B84?PQID=2167411631&collectionsTag=&format=PAGE>.

This article talks about how the Allies kept much of their work during WWII a secret from the world, including Turing's contributions at Bletchley Park in cracking the ENIGMA. This assisted us in writing our Conclusion when we talk about how knowledge of Turing's outstanding works was hidden from the public for many years.

Kelkar, Shreeharsh. "Difficult to Decode: Alan Turing's Life and Its Implications." *Harvard*, 2012. Accessed 14 Nov. 2019. <https://sitn.hms.harvard.edu/flash/2012/turing-biography/>.

This website published by Harvard gives a summary of Turing's life and how his Bombe and Turing machines have shaped our modern-day computer and machinery. We used this source as a guide to his life's works and was used to build up our draft of our content.

Keynes, Milton. Statue of Alan Turing. Buckinghamshire, 2015. Accessed 15 Mar. 2020.  
<https://www.geograph.org.uk/photo/4407971>.

This picture is of the statue of Alan Turing located in Bletchley Park. We used this photo to better emphasize how Turing's legacy was so important to WWII and the world of computer science.

“Konrad Zuse's Z3.” *Academic*. Accessed 3 Apr. 2020. [enacademic.com/dic.nsf/enwiki/4108496](http://enacademic.com/dic.nsf/enwiki/4108496).

This picture is of a replica of Konrad Zuse’s Z3, which is considered the world’s first programmable and functioning machines that was created based off Turing’s theories. We used this picture in our timeline to back up our thesis and show how Turing’s theories and creations changed the world and assisted many others that came soon after him.

Lycett, Andrew. “History – World Wars: Breaking Germany’s Enigma Code.” *BBC*, BBC, 17 Feb. 2011. Accessed 2 Dec. 2019.  
[www.bbc.co.uk/history/worldwars/wwtwo/enigma\\_01.shtml](http://www.bbc.co.uk/history/worldwars/wwtwo/enigma_01.shtml).

This site told us about the uses of the ENIGMA machine during WWII and how Axis forces used variations of the machine to send important encrypted messages to each other, as well as how the Allied forces desperately tried to break the codes.

McNab, Chris. “Bombe versus Enigma.” *History Study Center*, ProQuest, 2015. Accessed 1 Nov. 2019.  
<http://www.historystudycenter.com/search/proxyProquestPDF.do;jsessionid=7F5F82CB D312569627EAFC91991C1B84?PQID=3506334431&collectionsTag=&format=PAGE>.

This source helped provide us with a simplified but detailed explanation of how both the ENIGMA and Bombe machines worked. This source helped us with part of our explanations in the Background and Build-Up when we were giving context on how the early version of the ENIGMA and Polish Bomba machines functioned.

“Most Important Smartphone Models over the Years.” *Tech 21 Century*, 6 Feb. 2019, Accessed April 10, 2020, [www.tech21century.com/most-important-smartphones-over-the-years/](http://www.tech21century.com/most-important-smartphones-over-the-years/).

This website gave us an image of IBM Simon Personal Communicator, one of the earliest versions of a smart phone. This enhanced our project because it signified another important technological advancement on our timeline, which was having compact devices that were assisted with very primeval versions of AI.

“Motorola DynaTAC 8000X.” *Industrious Info*. Accessed 2 Apr. 2020.  
[www.industrious.info/13/06412-first-motorola-cell-phone-brick.html](http://www.industrious.info/13/06412-first-motorola-cell-phone-brick.html).

This image is of a Motorola DynaTAC 8000X, considered the world's first smartphone. We used this picture in our timeline to depict the journey that was taken for Turing's theories and ideas to reach the current state of technology.

Norlander, Thomas Eric. "AI Surveying: Artificial Intelligence in Business." *Department of Management Science and Statistic*, Sept. 2001. Accessed 22 Nov. 2019.  
<https://pdfs.semanticscholar.org/eec2/544d30289e3ded4995bc9f0c4abc3c64c897.pdf>.

This PDF talked about AI and its uses in the business industry, as well as a history of how it was developed. We learned that Turing invented the Turing test, which was and is still one of the most influential theories on computers and their intelligence that relates to AI.

O'Conner, Jerome. "Alan Turing-Enigma." *eLibrary*, 2000. Accessed 3 Nov. 2019.  
<https://explore-proquest-com.ezproxy.kcls.org/elibrary/document/217047633?searchid=1572810157&accountid=46>.

This article talks about Turing's life and what his personality was like, as well as his contributions during WWII and his breakthroughs in modern computing. We used this article to help us with our Short-Term and Long-Term Impacts which discuss the overall importance of Turing's work to the Allies during WWII and the history of computer science.

Robinson, Andrew. "The Enduring Enigma of Alan Turing." 18 Oct. 2014. Accessed 3 Nov. 2019.  
<https://explore-proquest-com.ezproxy.kcls.org/elibrary/document/1614923344?searchid=1572811117&accountid=46>.

This source talked about how Turing's contributions were coming to light in recent years and how he was finally being more recognized by the world after much of his work was overshadowed by the fact that he was gay and persecuted by his own government. This information helped us write our Conclusion when we were exploring Turing's later life and legacy.

Sale, Tony, Hodges, Andrew. "Bletchley Park and Its Museum." *History of Cryptography*. Accessed 20 Nov. 2019.  
<https://www.codesandciphers.org.uk/bletchleypark/>.

This secondary source incorporated sections about Bletchley Park itself and its museum, which included works by cryptanalysts. It is mainly visuals and information you would see during a tour provided by this museum.

Science Museum. "How did the Enigma Machine work?" *YouTube*. YouTube. 28 May 2019. Accessed 17 Jan. 2019  
<https://www.youtube.com/watch?v=CspaXNkC2ec&feature=youtu.be>

This video explained the uses of the Enigma machine and how it operated. We used this video as a media device for part of our exhibit, as well as to get a better understanding of the functionality of the Enigma machine.

Simkin, John. "Alan Turing." *Spartacus Educational*, Spartacus Educational, 2016. Accessed 14 Nov. 2019. [https://spartacus-educational.com/Alan\\_Turing.htm](https://spartacus-educational.com/Alan_Turing.htm).

This source used gave us a strong foundation for our research analysis about our topic and shows Alan Turing's life in a detailed manner. This source was used throughout our project, but mainly to build up a supportive foundation for our researching.

Simkin, John. "Enigma Machine." *Spartacus Educational*, Spartacus Educational, 2016. Accessed 14 Nov. 2019. [https://spartacus-educational.com/Enigma\\_Machine.htm](https://spartacus-educational.com/Enigma_Machine.htm).

This source gave a solid foundation for our research analysis about our topic and how the Enigma machine works, as well as the Bombe. This source was used throughout our project, but mainly to enforce our foundation of our research process.

Simmons, Gustavus J. "Developments during World Wars I and II." *Encyclopædia Britannica*, Encyclopædia Britannica, Inc., 17 Aug. 2016, Accessed 26 Nov. 2019.  
[www.britannica.com/topic/cryptology/Developments-during-World-Wars-I-and-II#ref392556](http://www.britannica.com/topic/cryptology/Developments-during-World-Wars-I-and-II#ref392556).

This site talked about the technological developments that were being made during WWI and WWII, particularly the encryption systems for military messages. This helped with our context and furthered our understanding of what kinds of coding systems armies were using before Turing developed the Bombe and cracked the ENIGMA.

Smith, Chris. "Cracking the Enigma Code: How Turing's Bombe Turned the Tide of WWII." *BT.com*, 2 Nov. 2017. Accessed 1 Nov. 2019. <http://home.bt.com/tec-gadgets-cracking-the-enigma-code-how-turings-bombe-turned-the-tide-of-wwii-11363990654704>.

This secondary source explained the visualization that the Allies took to approach the problem of the seemingly unbreakable Enigma code used by the Germans and the Nazis. We used this source to help explain multiple parts of our project, such as the short- and long-term impact and the build-up.

The Editors of Encyclopaedia Britannica. "Assembly Line." *Encyclopædia Britannica*, Encyclopædia Britannica, Inc., 1 Aug. 2018, Accessed April 10, 2020. [www.britannica.com/technology/assembly-line](http://www.britannica.com/technology/assembly-line).

This website included an image of an assembly line that had minimal manual labor. This helped our project because it represented an important advancement to the field of autonomous labor on our timeline.

"The Enigma of Alan Turing." *Central Intelligence Agency*, Central Intelligence Agency, 10 Apr. 2015. Accessed 31 Oct. 2019. <https://www.cia.gov/news-information/features-story-archive/2015-featured-story-archive/the-enigma-of-alan-turing-html>.

This secondary source described how Alan Turing cracked the Enigma while facing many hardships during his time at Bletchley Park. Since this source incorporated information on how the breakthrough benefited the Allies, we could better understand information in primary sources. This allowed for more in-depth analysis in short-term impact, and a better understanding of how Turing imagined the Bombe machine to function.

"Two Pieces of the ENIAC on Display." Philadelphia, 13 Dec. 2005. Accessed 2 Apr. 2020.

This picture depicts two parts that were used on the ENIAC, one of the first computers to build off of Turing's breakthroughs. We used this picture in our timeline where we display the technological impacts that Turing had on the world and the future.

"Ultra." *Britannica Library*, Encyclopædia Britannica, 21 Jan. 2010. Accessed 30 Nov. 2019. <https://library-eb-com.ezproxy.kcls.org/levels/referencecenter/article/Ultra/74173>.

This article included information about an Allied intelligence project called 'Ultra' that was dedicated to breaking Axis codes during WWII, including codes from the Germans, the Japanese, and the Italians. We used this information as Build Up for our project as we talked about how the Allies dedicated a lot of resources to decrypting enemy codes.

Van Allen, Fox. "IBM 5100." *TechRepublic*, 9 May 2017. Accessed 3 Apr. 2020.  
[www.techrepublic.com/pictures/the-evolution-of-the-laptop-computer/2/](http://www.techrepublic.com/pictures/the-evolution-of-the-laptop-computer/2/).

This image is of an IBM 5100, considered the world's first portable computer (despite it still needing to be plugged in). We used this image in our timeline to show Turing's theories and ideas in modern technology when a thinking machine is a reality, not a dream.

"What Is an Analytical Engine?" Computer Hope, 2 Oct. 2017. Accessed 2 Apr. 2020.  
[www.computerhope.com/jargon/a/analyten.htm](http://www.computerhope.com/jargon/a/analyten.htm).

This website supplied some basic information about the Analytical Engine. This source contributed to our context where we talk about the few people who attempted to create a thinking machine before Turing and how it inspired him to change the world.

Yarnhub, director. "Alan Turing - Betrayed by the Country He Saved." *YouTube*, YouTube, 30 Aug. 2019. Accessed 14 Nov. 2019. [www.youtube.com/watch?v=ynTAFPukXBk](http://www.youtube.com/watch?v=ynTAFPukXBk).

This video gave a short but solid summary of Turing's life and how his works changed lives. We used this video as part of our research foundation and laid the groundwork for our project.