Charles Babbage, Ada Lovelace, and the Dawn of Computing

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Abstract

This paper summarizes the product of the author's ongoing research project to create a Reacting to the Past (RTTP) historical role-playing game entitled *Charles Babbage, Ada Lovelace, and the Dawn of Computing*. According to the RTTP Website, RTTP "...consists of elaborate games, set in the past, in which students are assigned roles informed by classic texts in the history of ideas. Class sessions are run entirely by students; instructors advise and guide students and grade their oral and written work. It seeks to draw students into the past, promote engagement with big ideas, and improve intellectual and academic skills." In the Babbage game, students take on the personae of the key figures in early Victorian science and engineering, and debate whether or not the British government should provide funding for the development of Babbage's Difference and Analytical Engines.

Students in the game are divided into three groups. First, there are two factions, with preset opinions regarding Babbage's engines: a pro-Babbage faction and an anti-Babbage faction. Five students are indeterminates, playing the roles of the Prime Ministers who served during this time. Students in the factions strive to sway the indeterminates to their side, so that Babbage's engines will be funded (pro-Babbage faction) or not (anti-Babbage faction).

Game sessions take place at Babbage's home, the London Mechanic's Institute, and the Royal Society. The game can be played in six, seven, or eight class sessions, and includes three optional labs. There are 28 playable characters in the game. The game can be used in history of science or history of computing courses, and also in general-audience first-year seminar courses, to encourage students to study computing. The paper covers the background of RTTP games in general; some of the specifics of the Babbage game in particular; and includes insights from the first playtesting of the game during the author's fall 2017 first-year seminar course.

1 Introduction

Charles Babbage, Ada Lovelace, and the Dawn of Computing is a Reacting to the Past (RTTP) historical role-playing game created by the author. In the RTTP pedagogy, students are assigned roles rooted in history; they delve deeply into important historical texts; they make speeches and debate important, contentious historical ideas; and they win or lose the game based on their performance. The sections below cover the background of RTTP games in general, details the specifics of the Babbage game in particular, and cover insights from the first playtesting of the game during the author's fall 2017 first-year seminar course.

2 Reacting to the Past (RTTP) Games

According to the RTTP website, RTTP "…consists of elaborate games, set in the past, in which students are assigned roles informed by classic texts in the history of ideas. Class sessions are run entirely by students; instructors advise and guide students and grade their oral and written work. It seeks to draw students into the past, promote engagement with big ideas, and improve intellectual and academic skills." [1] Most RTTP games are so detailed that they require many class sessions to play; for example, the full version of the Babbage game requires 13 class sessions. However, there are condensed versions of many games (Babbage can be played in as few as six sessions), and there are micro games that can be played entirely in one class session. RTTP games are well suited to history courses, or, due to the emphasis on research, critical thinking, and communications, they are also ideal for first-year seminar courses.

After a few preparatory lectures, a RTTP game begins and the players are in charge; the instructor serves as adviser or "gamemaster." A RTTP game usually begins with some sort of "liminal experience," intended to show students that the upcoming experience is going to be different from what they are used to. For example, *The Threshold of Democracy: Athens in 403 B.C.* [2] begins with a pig sacrifice. (Students are encouraged to use their creativity to construct a "pig" to sacrifice; frosted sugar cookies are popular.) The Babbage game begins with a party at Charles Babbage's house, including a period-correct Georgian party game. Outcomes sometimes differ from the actual history; a postmortem session at the end of the game sets the record straight.

At the beginning of the course, students are given elaborate gamebooks which place them in moments of historical controversy and intellectual ferment. The Gamebook sets the historical stage for the game, outlines the rules, and includes annotated versions of relevant historical core texts. Before the game begins, each student also receives a role and a detailed role sheet describing their character, their affiliations, and their objectives for the game.

Then, the class becomes a public body of some sort; students, in role, become particular persons from the period, often as members of a faction. Their purpose is to advance a policy agenda and achieve their victory objectives. To do so, they will undertake research and

write speeches and position papers; and they will also give formal speeches, participate in informal debates and negotiations, and otherwise work to win the game.

The uniqueness of the RTTP pedagogy means that the instructor should be aware of the differences between RTTP and a traditional course before attempting to use a RTTP game. Some of these differences are discussed in the next section.

2.1 Differences Between RTTP and Traditional Pedagogies

RTTP is clearly a different pedagogy, the polar opposite of a traditional "sage on the stage" lecture approach. As such, it is important for potential RTTP instructors to understand the differences and the tradeoffs involved.

Firstly, it is important to emphasize that during a RTTP game, the students are largely in charge. Once the game begins, students (while in character) preside over each of the class sessions in the game. The presiding officer may be either elected by their peers or be serving as the presiding officer in the session by virtue of the game's design. The presiding officer manages the game session, ensuring that each of the scheduled speeches or discussions takes place, and makes sure that everyone who wishes to contribute is able to speak.

The fact that students are running the game sessions implies that instructors are not the focus. Instead, once the game starts, the instructor becomes the gamemaster (GM). The GM typically sits in the back of the classroom, observing, taking notes, and evaluating the speeches given by the students. However, the GM is not completely removed from the conduct of the class; during a game session, the GM might pass notes to certain students to spur them into action, or announce the effects of actions taken by the students on the environment of the game (e.g., in the Galileo game, the Pope's reliance on Spanish support to put down Protestant armies has created a schism in the church), or, more rarely, interrupt the game and redirect the proceedings if the game has gone too far off track.

It is also important for instructors to be aware of, and acceptant of, the depth versus breadth tradeoff that using RTTP entails. Since a RTTP game will typically take up a large portion of a semester, the amount of content that can be covered in a class using RTTP will likely be less than the amount of content that could be covered in a lecture-based course. But, students participating in a course using RTTP will delve much more deeply into the content than they would in a traditional course. Also, the additional critical thinking and communications skills students develop during a RTTP game are very valuable, and likely more important to students' future lives than covering more content (that will likely be forgotten by the students shortly after the course's final exam).

Another issue that instructors should consider is class size. Most RTTP games have at least 28 playable roles, and so small class sizes work best for RTTP games. RTTP can be used in larger classes, however; a variety of strategies have been developed along these lines. For example, the instructor may assign more than one student to play each role. Then, the two or three students assigned to the same role play that character as a team, dividing up

2

the responsibilities for making speeches, etc. amongst themselves. Alternatively, if the instructor has a teaching assistant or other facilitator and enough classroom space, the class may be divided into two or more groups that each play their own version of the game concurrently.

Once an instructor decides to use a RTTP game, they can investigate the materials that make up a game. These materials are described below.

2.2 The Components of a RTTP Game

There are several RTTP games that have been formally published; these are enumerated on the RTTP website [1]. Many, many more games, covering a wide variety of subjects, have not yet been formally published; these are detailed on the "Big List of Reacting Games" (the BLORG), also accessible from the RTTP website. For formally published games, gamebooks are available from traditional textbook publishers and Instructor's Materials are available through the faculty side of the RTTP website. For unpublished the games on the BLORG, all of the materials are available electronically from each game's author(s).

There are three components of a RTTP game: The Gamebook, the Instructor's Guide, and the Instructor's Materials. Each of these is briefly described below.

2.2.1 The Gamebook

The Gamebook for a RTTP game is the primary student-facing component of the game. Each student purchases or receives a copy of the Gamebook at the beginning of their course. The Gamebook, typically limited to 80,000 words, sets the stage for the game via a historical fiction vignette, overviews the relevant history leading up to the start of the game, details the rules and procedures of the game, overviews the different characters and factions that are involved, and includes annotated versions of the core texts that the students are expected to read before the game.

Students are expected to thoroughly read the Gamebook, including the core texts, before the game begins. To ensure that students do the reading, instructors often give a reading comprehension quiz before the game starts. These quizzes are usually taken by students working together with their faction members, and faction performance on the reading quiz often has consequences in the game. For example, in the Babbage game, the faction with the highest score on the quiz wins an Influence Point (IP) on the first day of the game, giving them a competitive advantage over the other factions.

2.2.2 The Instructor's Guide

The Instructor's Guide (IG) for a RTTP game is the primary instructor-facing component of the game. The IG, typically limited to 20,000 words, introduces the RTTP pedagogy, discusses how to prepare for the game, how to manage the game while it is running, and how to conduct the post-mortem debriefing at the end of the game. The IG includes a detailed, day-by-day schedule of activities, describing how each game session should work.

3

The IG also details the subversive secrets that certain characters have, unbeknownst to the other characters in the game. For example, in the Babbage game, Dionysius Lardner can win the game, apart from his pro-Babbage faction, if he is able to successfully use and document at least three flawed arguments (straw man, slippery slope, false dilemma, etc.) without being caught by the other characters.

In addition to the IG, the instructor should be thoroughly familiar with the students' Gamebook before the game begins.

2.2.3 Instructor's Materials

The Instructor's Materials (IM) document contains other student-facing materials, handouts that are distributed to everyone in the class or to specific characters. The IM, typically limited to 60,000 words, contains the role sheets for each character, and other handouts.

Each role sheet is to be read only by the student playing that role, since roles often entail secrets that should not be divulged to the other players in the game. Students receive their role sheets before the game begins, so they are able to fully digest who their character is, and what their objectives in the game are.

The other handouts in the IM may include details for factions, the reading quizzes to be given before the start of the game, or whatever other materials might be required to conduct the game. For example, in the Babbage game, one of the IM handouts is a sheet explaining how to play the Georgian party game "I Love my Love with an A." This party game is used as the liminal experience in the first Babbage game session.

Now that a few of the concepts and details of RTTP games in general have been introduced, more specifics of the Babbage game are presented in the following section.

3 Specifics of the Babbage Game

In the *Charles Babbage, Ada Lovelace, and the Dawn of Computing* game, students take on the personae of the key figures in early Victorian science and engineering, and debate whether or not the British government should provide funding for the development of Babbage's Difference and Analytical Engines. Before discussing the characters in the game and the game's structure, we first briefly introduce the Difference and Analytical Engines.

3.1 The Difference and Analytical Engines

In 1820 or 1821, upon encountering many errors in the printed mathematical tables used by navigators, astronomers, and other men of science, Charles Babbage first conceived of the Difference Engine. "I wish to God the calculations had been executed by steam" is the associated, and probably apocryphal, quotation. [3] The Difference Engine was designed to calculate, typeset, and produce printing plates for mathematical tables. The machine would have automated the method of finite differences, which allows the calculation of successive values of polynomial functions using only addition and subtraction. In order to

4

produce the values needed for tables, such as tables of logarithms, skilled mathematicians would produce Taylor series approximations of the required functions, resulting in polynomials that could then be computed using the Difference Engine. Upon the recommendation of the Royal Society of London, Babbage received funding from the British government to produce a working Difference Engine. Despite receiving more than £17,000 of government funding, the Difference Engine was never finished. A small, six-figure working model of the Difference Engine was constructed, however; Babbage kept the working Difference Engine fragment in his home on Dorset Street in London. In the 1830s and 1840s, Babbage was famous for the parties he hosted there, and he especially delighted in demonstrating how the Difference Engine fragment worked to those in attendance. [4]

Starting in the late 1830s, and continuing through his death in 1871, Babbage turned his attention to his Analytical Engine, which would have been a true, Turing-complete computer. [5] The Analytical Engine had a "store," corresponding to today's RAM, and a "mill," corresponding to today's CPUs. Instructions and variables would be input into the machine via punch cards, inspired by those used in the Jacquard loom. Amazingly, the instruction set the Analytical Engine would have used [6] is immediately recognizable by anyone who has learned assembly language programming. Despite Babbage's repeated requests for government funding, no complete working version of the Analytical Engine was ever constructed.

Babbage's struggle to obtain the funding required to complete the Difference and Analytical Engines is the central intellectual tension in the Babbage game. The characters and factions in the game are described in the next section.

3.2 Factions and Characters

In the current version of *Charles Babbage, Ada Lovelace, and the Dawn of Computing*, there are 22 playable characters. Three more are in development, and three beyond that will be created before the start of the fall 2018 academic semester. In total, there will be 28 playable characters. Each of the characters is either a real figure from history, or, in the case of Captain Swing, the personification of a political movement of the time.

The characters are divided into three groups: the pro-Babbage faction, the anti-Babbage faction, and the indeterminates. The pro-Babbage faction is a collection of men of science, engineers, and personal friends of Charles Babbage. This group is committed to the development of Babbage's computing engines, recognizing how important they will be. The faction members also recognize that developing the Difference Engine or the Analytical Engine will be expensive, beyond the capacity of private financing.

The anti-Babbage faction is a collection of men of science, clergy, and political figures. This group is against the British government paying any more money for the development of Babbage's computing engines. Anti-Babbage faction members have different reasons for opposing the engines: some do not think the engines will be valuable or necessary for the advancement of science in Britain; some think the engines are potentially valuable, but

do not think that projects such as this should be supported by the government; and some are generally against the increasing mechanization of British society, as it forces working people from their jobs.

In the Babbage game, the characters that serve in the role of Prime Minister are indeterminate. That means that these characters have no pre-decided position regarding Babbage's engines, although each character does have some general political leanings that may inform his opinions on the subject. The members of the pro- and anti-Babbage factions must attempt to convince the indeterminates that their point of view should prevail, since the indeterminate serving as Prime Minister has the power to make decisions regarding the funding of Babbage's projects.

The 22 fully-developed characters in the Babbage game are described below.

3.2.1 Pro-Babbage Faction Members

The following characters belong to the pro-Babbage faction.

- *John Couch Adams* John Couch (pronounced "cooch") Adams is a British astronomer and mathematician, best known for his co-discovery with Urbain Le Verrier of the planet Neptune in 1846.
- *Charles Babbage* Charles Babbage is a British polymath -- a person whose expertise spans a significant number of different subject areas -- and the inventor of two types of calculating machines. First, Babbage invented the Difference Engine, a device capable of automatically calculating and printing certain types of mathematical tables, and then the Analytical Engine, a true proto-computer.
- *Isambard Kingdom (I. K.) Brunel* I. K. Brunel is perhaps the most accomplished mechanical and civil engineer in Britain during the time of the game. Brunel, a close personal friend of Charles Babbage, is responsible for completing the Thames Tunnel project, for building the Great Western Railway, and for the construction of the steamship S. S. Great Western.
- *Joseph Clement* Joseph Clement is the extremely capable toolmaker, draftsman, engineer, and industrialist hired by Charles Babbage to build his Difference Engine.
- *Andrew Crosse* Andrew Crosse is an amateur man of science, best known for his experiments with electricity. Mary Shelley, the author of the novel *Frankenstein*, is an acquaintance, and her husband Percy Bysshe Shelley attended one of Crosse's lectures on atmospheric electricity in 1814; this may or may not have helped to influence later editions of the famous novel.
- *Michael Faraday* Michael Faraday is an extremely influential English man of science; of all the characters in this game, his influence is the greatest in the 21st-century world. His work focuses on chemistry and electricity.
- *John Frederick William Herschel* John Frederick William Herschel is another British polymath, and close friend of Charles Babbage. He and Babbage, among others, formed the Analytical Society while undergraduate students at Cambridge. Herschel studied mathematics, astronomy, chemistry, botany, and more. Herschel is the leader of the pro-Babbage faction.

6

- *Dionysius Lardner* Dionysius Lardner is a member of the Royal Society of London and a professor at the University of London. Lardner is a scientific populist and the first scientific journalist.
- *Augusta Ada King-Noel, Countess of Lovelace* Augusta Ada King-Noel, Countess of Lovelace, is the only legitimate daughter of the "mad, bad, and dangerous to know" romantic poet, Lord Byron. Lovelace is a close friend of Charles Babbage, and in 1843, she translated an article on Babbage's Analytical Engine by Luigi Federico Menabrea, and added her own voluminous notes to the translation. The notes contain what is now considered the world's first computer program.
- *Mary Somerville* Mary Fairfax Greig Somerville is a Scottish polymath. She is very unusual for the time, having published several very influential papers and books. Somerville served as one of Ada Lovelace's tutors, and introduced her to Charles Babbage at one of his Dorset Street parties.

3.2.2 Anti-Babbage Faction

The following characters are members of the anti-Babbage faction.

- *George Biddell Airy* George Biddell Airy is an English mathematician and, as of 1835, the Astronomer Royal. Airy, holder of the Lucasian Professorship of Mathematics at Cambridge before Charles Babbage assumed the chair in 1828, is the leader of the anti-Babbage faction.
- *Reverend William Buckland* The Reverend Doctor William Buckland is an English clergyman, theologian, geologist, and paleontologist. Buckland published the first full account of a fossilized dinosaur, which he termed *Megalosaurus*.
- *William Frend* William Frend is an English unitarian clergyman, political radical, and author of the algebra textbook, *Principles of Algebra*. Frend, along with Mary Somerville, served as one of Ada Lovelace's mathematics tutors.
- *Davies Gilbert* Davies Gilbert is a British botanist, geologist, mathematician, civil servant, politician, author, and from 1827 through 1830, president of the Royal Society of London.
- *Edward Sabine* Edward Sabine is an Irish military man, geologist, and astronomer. He served as the on-board astronomer on expeditions to attempt to discover the Northwest Passage under Sir John Ross in 1818 and again under Sir William Edward Parry in 1819 and 1820.
- *Prince Augustus Frederick, Duke of Sussex* Prince Augustus Frederick, Duke of Sussex, is the sixth son of "mad" King George III, who reigned from 1760 until 1820. Although not a man of science, Sussex does have intellectual pursuits, chiefly in biblical studies and the Hebrew language.
- *Captain Swing* Captain Swing represents the spirit and ideas of the farmers who participated in the "Swing Riots" across England in 1830 and 1831, starting fires and breaking threshing machines, protesting for increased wages, against restrictive Poor Laws, and against the increasing use of threshing machines in agriculture. Several of the threatening letters sent by the protesters were signed with the *nom de guerre* "Captain Swing."

3.2.3 Indeterminates

The following five characters are the indeterminates in the Babbage game.

- *Lord Charles Grey, 2nd Earl Grey* Lord Charles Grey, 2nd Earl Grey is a Whig MP, and the namesake of Earl Grey tea.
- *Sir Robert Peel, 2nd Baronet* Sir Robert Peel, 2nd Baronet is a Tory MP.
- *Lord Frederick John Robinson, 1st Earl of Ripon* Lord Frederick John Robinson, 1st Earl of Ripon is a Tory MP.
- *Lord John Russell, 1st Earl Russell* Lord John Russell, 1st Earl Russell is a Whig MP.
- *Field Marshal Arthur Wellesley, 1st Duke of Wellington* Field Marshal Arthur Wellesley, 1st Duke of Wellington is the biggest hero of the French Wars and Tory MP.

3.2.4 Role Assignment

The Babbage game can be played with as few as 14 students, and, once the final roles are completed, with as many as 28 students. The GM must assign roles to students before the game begins and distribute the appropriate role sheets. Table 1 shows which roles are included in the game, depending of the number of students in the class.

The three characters which have been planned, but not yet implemented, are the ghost of Lord Bryon, William King, and one of the Furies. Byron's ghost will be a proponent of imagination, while King will be a champion of reason over imagination. These two characters reflect another tension that was evident in the early Victorian age: reason versus romance. The Fury will be one of the women employed by Ada Lovelace's mother, Anne Isabella Milbanke, Lady Byron, to raise Ada [8]. She will introduce other characters to the rules of proper British society, and also serve as a protector of Ada, making sure that other characters (particularly those of "low birth") have minimal contact with Ada. The last three roles will be created before the beginning of the fall 2018 academic semester and are not included in the role allocation table.

As the last six roles are incorporated into the game, the allocation table shown in Table 1 will likely be changed. The Instructor's Guide for the game will always contain the authoritative role allocation table for the game.

The game sessions and other activities involved in the Babbage game are described in the next section.

Role	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Adams				X	X	X	X	X	X	X	X	X	X	X	X
Airy	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Babbage	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Brunel		X	X	X	X	X	X	X	X	X	X	X	X	X	X
Buckland			X	X	X	X	X	X	X	X	X	X	X	X	X
Clement	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Crosse										X	X	X	X	X	X	X
Faraday								X	X	X	X	X	X	X	X
Frend					X	X	X	X	X	X	X	X	X	X	X
Gilbert	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Grey	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Herschel	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Lardner	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Lovelace	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Peel	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Robinson	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Russell	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sabine							X	X	X	X	X	X	X	X	X
Somerville						X	X	X	X	X	X	X	X	X	X
Sussex	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Swing	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Wellesley	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
King											X	X	X	X	X
Byron's Ghost											X	X	X	X	X
Fury												X	X	X	X

Table 1: Role Allocation Table

3.3 Game Structure

Like all RTTP games, the Babbage game begins with one or more pre-game sessions. In these sessions, the GM briefly covers the relevant history up until the beginning of the game (1828, in the case of the Babbage game), assigns roles, and administers the reading quiz. In the Babbage game, the students take the quiz in their factions, with the indeterminates forming a temporary faction for the purpose of the quiz. The faction scoring the highest on the reading quiz earns an Influence Point (IP). IPs are the currency of the game; they can be used to force the PM to decide in a certain way when funding for Babbage's engines is at stake.

After the pre-game session(s), the game begins. The game sessions take place at a variety of locations in London: Babbage's home at 1 Dorset Street, the London Mechanic's Institute, and the Royal Society of London. The sessions cover a wide period of time, occurring in 1828, 1830, and 1846. The sessions comprising the game are outlined in Table 2.

Game session 4.5 is optional. During this session, the new president of the Royal Society is elected; the candidates are the pro-Babbage faction member John Herschel, and the anti-Babbage member the Duke of Sussex. One of the secrets of the game is that the game is engineered so that Sussex is elected (as he was in the actual event). The GM, Davies Gilbert, and Charles Babbage conspire to make sure that this outcome is achieved. If GS 4.5 is not included in the game, then the GM merely announces at the start of GS 5 that Sussex has been elected as president of the Royal.

The three labs take place outside of the game (i.e., students are not in character during the labs), and these sessions are optional. In Lab 1, students learn the basics of the method of finite differences, and Taylor Series approximations. Lab 1 includes some optional programming assignments, if students have basic programming knowledge beforehand. In Lab 2, students use a web simulation of the Difference Engine [7] to understand what the Difference Engine would have produced. In Lab 3, students use a different web simulator [6] to understand the organization and operation of the Analytical Engine. During this lab, students also create some simple programs for the Engine.

Before turning to the insights gleaned from the first playtesting of the game, we briefly summarize the basic mechanics of the game in the next section.

3.4 Basic Game Mechanics

Influence Points (IPs) are the currency of the game. Characters and factions can earn IPs in various ways, such as:

- By scoring the highest on the reading quiz at the end of the setup sessions
- By winning the party game at Babbage's party during GS 1
- By winning the persuasiveness metric vote for the most persuasive presentation during a game session

- By being identified by the GM for making the best presentation during a game session
- If the Royal Society passes a resolution favorable to a faction of an individual character
- If a character defects from one faction to another
- By virtue of their wealth or political power, Gilbert, Sussex, Grey, Peel, Robinson, Russell, and Wellesley all begin the game with one IP each

Session (year) / Location	Presiding Character	Theme
GS 1 (1828) / 1 Dorset Street	Babbage	Babbage's party
Lab 1	n/a	Finite Differences
GS 2 (1828) / Mechanic's Institute	Lardner	Public Lectures 1
Lab 2	n/a	The Difference Engine
GS 3 (1828) / Royal Society	Gilbert	The Difference Engine
GS 4 (1830) / Royal Society	Gilbert	Celebrating the RS
GS 4.5 (1830) / Royal Society	Gilbert	RS Presidency
Lab 3	n/a	The Analytical Engine
GS 5 (1846) / Mechanic's Institute	Brunel	Public Lectures 2
GS 6 (1846) / Royal Society	RS President	The Analytical Engine
GS 7 (1846) / Royal Society	RS President	The Analytical Engine

Table 2: Overview of Game Sessions.

IPs are spent at the end of GS 3, 5, and 7. No one has to spend their IPs; they can be saved to be more impactful for later decisions. The way the IPs are spent can influence the decision the PM must make at the end of GS 3, 5, and 7. Effectively, if a faction does very well and wins most of the IPs, they may politically box in the PM, forcing him to make a decision favorable to them.

At the end of each game session, the indeterminates vote on the most persuasive presentation of the session. The winner of this vote earns an IP. This ensures that the factions try their best to persuade the indeterminates that their way of thinking is the correct one.

During GS 5, Clement defects from the pro-Babbage faction to the anti-Babbage faction. He makes a speech during the game session, outlining the reasons why he left the employ of Babbage, and his defection earns the anti-Babbage faction an IP. This defection reflects Clement's actual departure from the Difference Engine project, which dealt the enterprise a fatal blow.

Generally speaking, characters in the factions win the game if their faction wins. The pro-Babbage faction wins if the government decides to fund Babbage's projects on at least two of the three opportunities. The anti-Babbage faction wins if the government declines to fund Babbage on at least two of the three opportunities. Certain other characters, such as Lardner, Airy, and Adams, have other paths to victory that are not tied to their factions.

Indeterminates win in another way. In each of the first five game sessions, a PM is randomly selected from the indeterminates. The PM then makes a PM speech at the beginning of the session, explaining the priorities and goals of his government. Near the end of GS 7, all of the characters with franchise vote for the PM who made the best PM speech during the game. The winner of this vote is the winning indeterminate for the game. If two or more PMs are tied for first place, then all of the tied PMs meet their victory conditions.

The above is only a brief summary of the game. A full coverage of the game can be found in the Gamebook, Instructor's Guide, and Instructor's Materials for the game.

4 Insights from the First Playtesting

The author used the Babbage game for the first time in his fall 2017 first-year seminar course. Each first-year student must enroll in one of the sections of this course during their first semester. The course is designed to introduce students to college-level writing, discussion, critical thinking, and critical reading, making it a perfect place to employ a RTTP game. The author has used other RTTP games in the past, including *Charles Darwin, the Copley Medal, and the Rise of Naturalism, 1861-1864*[9] and *Trial of Galileo: Aristotelianism, the New Cosmology, and the Catholic Church, 1616-33* [10]. One of the additional goals of the Babbage game is to help encourage students in the author's general-enrollment first year seminar course to investigate pursuing a computer science major or minor.

During the fall 2017 course, only 14 students were enrolled. To fill out the game sessions, and to test more of the roles, the author invited other faculty and RTTP veteran students to perform one-day "guest star" roles. In these cases, the guest came to the class for their assigned session, made their speech, and participated in that day's debates. Their speeches were developed in coordination with the author, since the guests did not have the opportunity or time to do the deep research required of the other characters. This caused some friction with the first-year students, as they were often overmatched by the guest stars, even though they in fact knew more about the subject than the guests. On the other hand, their contributions were vital for the author, to see how more of the characters in the game performed.

Most game sessions and debates went well. It is gratifying to watch students debate about elements of early Victorian history, continuing their conversations beyond the end of class. However, the engineered outcome of GS 4.5, where the new president of the Royal Society is elected, was contentious. The student playing Herschel, in particular, was very upset at the way the election unfolded. The GM and the course's TA both talked with the student, explaining to him how the outcome was intentionally designed to mirror history. (In the actual event, Babbage assumed that Herschel would win the election easily, and so wrote his RS friends that lived outside of London, telling them not to bother to make the trip in to vote; this removed enough votes from Herschel's side that Sussex was elected.) In the future, more care might be taken with the student playing Herschel to avoid such drama.

The biggest change for the fall 2018 semester, other than adding the final six roles to the game, will be to change the course title. In 2017, the course was named after the game: *Charles Babbage, Ada Lovelace, and the Dawn of Computing*. The inclusion of the word "computing" seems to have discouraged female students from enrolling in the course; of the 14 students enrolled, 13 were male. In the fall of 2018, the author plans to play both the Galileo and Babbage games in his course, with a title something like *Rejected Rebels: Why the Right Idea Sometimes Loses*.

5 Conclusion

Charles Babbage, Ada Lovelace, and the Dawn of Computing is a RTTP game revolving around the struggles of Charles Babbage to fund and build his Difference and Analytical Engines. The game is an excellent fit for a first-year seminar course, as it truly encourages students to develop their college-level writing, discussion, critical thinking, and critical reading skills. The "gamification" of the content provides extra motivation for students to engage in these activities; as soon as one labels something as a game, students want to win, and in order to win, they have to know more about the subject than their opponents. In addition, there is a peer-pressure factor, as students in one of the factions push faction members that are neglecting their duties to pick up the pace. The author hopes that, over time, using the game and the computer-science-related content in it, will result in more students, who would normally not even consider a major or minor in computer science, to investigate the field.

Instructors wishing to investigate the materials for the game (Gamebook, Instructor's Guide, and Instructor's Materials) should email the author directly.

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