Charles Babbage, Ada Lovelace, and the Dawn of Computing

SIGCSE Special Project Grant

End-of-Project Report

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Introduction

My $3,000 SIGCSE Special Project award, received in June 2016, allowed me to create a Reacting to the Past (RTTP) role-playing game regarding Charles Babbage and his quest to build his Difference and Analytical Engines in the early- to mid-1800s. The grant paid for an adjunct instructor during the fall 2016 semester, giving me one course release time in that semester, as well as books and office supplies related to the development of the game. The game materials include three books (student gamebook, instructor's guide, and instructor's materials), plus ancillary materials such as programming lab solutions. The game exists in prototype form, and after I have play-tested the game in my fall 2017 first-year seminar course, it will be available for other instructors to use. The objective of the grant was to produce the game; this report describes how the objective was met.

Reacting to the Past Games

According to the Reacting to the Past Website hosted by Barnard College,

> Reacting to the Past (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. Reacting to the Past was honored with the 2004 Theodore Hesburgh Award (TIAA-CREF) for outstanding innovation in higher education.

RTTP games begin with a few days of "pre-game" introduction, and then revolve around debate, with groups of students often divided into factions aligned to different sides of the issue at hand. For example, the Galileo game revolves around Galileo's trials by the Catholic church in 1616 and 1632. The factions are the Conservatives (anti-Galileo), Linceans (pro-Galileo), and Moderates. There are also some "indeterminates," with no pre-assigned opinion. The action takes place at the College of Rome, and through a series of debates and votes, the Cardinals of the church decide Galileo's fate. After the game, a "post-mortem" compares what happened in the game to the actual historic record. In the Galileo game, there are also two optional labs, where students learn about lenses, telescopes, and measuring astronomical distance via stellar parallax.

Although RTTP games are mostly geared to the teaching of history, there are several STEM-related games, funded by the NSF. Samples include games about the status of Pluto as a planet, acid rain in Europe, the USDA Food Pyramid, and more. Many instructors have found the pedagogy to be simultaneously engaging and rigorous. It is not unusual for students to continue their debates well beyond the time allotted for a class session. The games are pedagogically engaging, and often lead students to delve more deeply into their subject matter than is the case in traditional lecture courses. RTTP games are used at all levels of university curriculum, but have proven to be especially useful in first-year seminar courses designed to introduce students to college-level reading, writing, critical thinking, and speaking.

I will use the *Charles Babbage, Ada Lovelace, and the Dawn of Computing* game for the first time in the fall 2017 semester in my first-year seminar course.

Brief Overview of the Game

Charles Babbage, Ada Lovelace, and the Dawn of Computing takes place in early nineteenth-century Britain, focusing on the calculating engines designed by Charles Babbage. The central intellectual collisions in the game concern the nature of science and scientists (are they talented, wealthy amateurs, or is science a profession?) and whether and to what degree science and engineering projects should be subsidized by the government. The main question in the game is whether or not Charles Babbage should be awarded funds from the British government for the development of his Difference Engine (an automated calculator capable of automatically creating, typesetting, and printing mathematical tables) and / or Analytical Engine (a true proto-computer), during the early to mid-1800s.

The Engines, at a minimum, would have "mechanized number," allowing rapid, automatic, error-free production of mathematical tables to be used in navigation, astronomy, and other applications. Ada Lovelace, regarded as the world's first computer programmer, could envision applications of the Analytical Engine beyond mere mathematics, however. In the notes to her English translation of Luigi Federico Menabrea's article *Sketch of the Analytical Engine Invented By Charles Babbage, Esq.*, Lovelace realized that the Engine could operate on symbols in an abstract manner, that it "might act upon other things besides number... the Engine might

compose elaborate and scientific pieces of music of any degree of complexity or extent." She also foresaw applications in business, drawing graphics, and more. In addition, the precision mechanical engineering work done on the engines had profound impacts on the state of engineering in the UK and around the world. The mind boggles at the prospects had an Analytical Engine ever actually been built. What would the consequences of a steam-powered, mechanical computer have been in Victorian England? One can easily get lost in the "steam-punk" possibilities of a 100-year head start in computing technology.

Players in this game may belong to one of two factions, or may be indeterminate. The pro-Babbage faction wants the government to provide funding adequate for the construction of one or both of Babbage's Engines. The anti-Babbage faction wants the opposite -- no funding for either Engine, either because they do not feel the Engines are that important, or because they do not feel the government should provide funding for such projects. Indeterminates have no set position on this issue, and are open to persuasion by the factions.

The game covers a broad span of time, from 1828 through 1846. There are six, seven, or eight game sessions and three optional labs, briefly described in Table 1 below. A condensed version of the game would have GS 1, 2, 3, 5, 6, and 7, and no labs. An extended version of the game would have all eight game sessions and all three labs. This allows flexibility in fitting the game into one's specific course.

The Products of This Work

In accordance with the editorial standards established by the Reacting to the Past consortium, the game consists of three main products: the student gamebook, the instructor's guide, and a book of instructor's materials. These materials, in their current state, are included with this report.

The gamebook is the primary student-facing component of the game. Each student in the class will have a copy. The gamebook contains introductory material, including a brief overview of the game, a map of the United Kingdom, and a first-person "you are there" prologue designed to help the students place themselves in Britain during the 1820s.

Next, the gamebook has a section on the historical background, with a chronology of events related to the development of calculating technology, and a narrative outlining the history of calculating technology, the state of the United Kingdom during the period of the game, and brief biographies of Charles Babbage and Ada Lovelace.

Then, in the third section, the game itself is described in more detail. The major issues for debate, the rules of the game, a more detailed outline of the game sessions, assignments, and counterfactuals are described in this section.

The fourth major section of the gamebook describes the roles and factions in the game -- the characters students can play and the groups they belong to.

The fifth section will contain significant portions of the core texts involved in the game, including Babbage's autobiography *Passages from the Life of a Philosopher*, Menabrea's article *Sketch of the Analytical Engine Invented by Charles Babbage, esq.*, including Lovelace's notes, and perhaps others. During the fall 2017 semester, students will use the text *Charles Babbage on the Principles and Development of the Calculator: And Other Seminal Writings*, by Phillip Morrison, Emily Morrison, and Charles Babbage, instead of relying on the core texts section of the gamebook.

Table 1: Overview of game sessions

Session (year) / location	Presiding character	Theme
GS 1 (1828) / 1 Dorset Street	Charles Babbage	Babbage's party
Lab 1 *(optional)*	n/a	Finite differences
GS 2 (1828) / Mechanic's Institute	Dionysius Lardner	Public lectures 1
Lab 2 *(optional)*	n/a	Difference Engine
GS 3 (1828) / Royal Society	Davies Gilbert	RS approval for DE funding PM decision
GS 4 (1830) / Royal Society *(optional session)*	Davies Gilbert	Celebrating the RS
GS 4.5 (1830) / Royal Society *(optional session)*	Davies Gilbert	Election of new RS president
Lab 3 *(optional)*	n/a	Analytical Engine
GS 5 (1846) / Mechanic's Institute	Isambard Kingdom Brunel	Public lectures 2 PM decision
GS 6 (1846) / Royal Society	RS president	Usefulness of the Analytical Engine
GS 7 (1846) / Royal Society	RS president	Final debates re. AE funding PM decision

The gamebook concludes with a bibliography, an appendix of abbreviations and titles, and acknowledgements.

The instructor's guide is the instructor's main reference for the game, with detailed instructions on how to run the game in the classroom. The introduction section begins with materials on how to teach using the RTTP pedagogy in general, and a brief introduction to the *Charles Babbage, Ada Lovelace, and the Dawn of Computing* game in particular, including the learning objectives and key concepts of the game.

The second section of the instructor's guide details what the instructor should do beforehand to play the game successfully. Issues such as class meeting times and durations, classroom selection, library reserves, etc. are covered, as well as standard, condensed, and extended versions of the game schedule. Then, instructor's-eyes-only descriptions of the characters and factions are laid out. This section concludes with an instructor's take on the rules and procedures of the game, and the reading and writing assignments associated with the game.

The third section of the instructor's guide provides day-by-day instructions for managing the game as it is being played. This section includes hints on what materials will be needed for each class session, what should happen when during each game session, and so on.

The final section of the instructor's guide deals with the debriefing or "post-mortem" sessions that follow the game. It is possible that the characters in the game rewrite history, in this case, it is possible that the pro-Babbage faction could prevail, earning funding for his computing engines far past the point at which the money was cut of in reality. The post-mortem sessions help to reset the historical context and discuss what really happened. The post-mortem is also when students reveal secret aspects of their roles. For example, during the post-mortem, Dionysius Lardner will reveal that one of his goals during the game was to successfully make two or more flawed arguments (straw-man, slippery slope, etc.) without being called out by the other characters.

The instructor's materials book primarily contains handouts that the instructor will give to the students. It includes role sheets for each character in the game, as well as other handouts, such as the instructions for the *I Love my Love with an A* party game that begins the first game session, lab instructions, and the secret language of science handout for characters that belong to the "men of science" community in the game. Other materials here will include a faction quiz, a pre-game quiz that can be given to the students before the game starts to help ensure that they do the required reading.

Future Work: Short Term

Some portions of the game materials, particularly in the instructor-facing books, have yet to be completed. I will continue to work on these materials through the summer, and during the first part of the fall semester. High on the list of priorities before the game is played the first time are:

strategy advice sections for the characters that will be in the game during my fall first-year seminar course, completing the secret MOS language handout, and a faction quiz to be given at the end of the pre-game sessions, and materials for the second and third labs.

The students in my first-year seminar course will not only be playing the game, they will help to develop materials for future versions of the game. For example, they will help with development of the faction quiz -- as they read the assigned readings in the weeks before the game, they will write one or two pages on each section of the reading. Part of this writing will be a series of questions that might be included in the faction quiz. Secondly, students will help to develop the strategy advice for their characters. A post-game writing assignment will require each student to develop, with the advantage of hindsight, guidance on how to play the role for future students.

After the fall 2017 semester, the game will be playable by other instructors. It will continue to evolve, however, as described in the next section.

Future Work: Long Term

For the 2017-2018 academic year, I was selected as the Ardis Bulter James Endowed Chair for Advancement of the Liberal and Fine Arts at Doane University. This chair entails funding for a one course release during each semester, plus funding for travel and for books, materials, and so on. This will allow me to continue to work on the *Charles Babbage, Ada Lovelace, and the Dawn of Computing* game.

Firstly, I will use this time to incorporate lessons learned from the fall 2017 into the game materials. Then, I will turn towards adding more material to the game.

One task will be to select, annotate, and incorporate the core texts into the gamebook. The RTTP consortium places word count limits on each section, so this will have to be done carefully. Feedback from the fall 2017 game will be invaluable in this exercise.

The map will need to be improved; hopefully, as the game moves up through the consortium's phases of game development, the editors from the official RTTP publishers can prove helpful here.

A major evolution of the game will be to add more characters. Currently there are 22 roles, but the RTTP consortium requires 28 characters before moving up in their five-stage path to commercial publication of a game. Morer characters will allow the game to be played in larger sections. There are a plethora of very interesting characters that can easily be added, and so this should not be too difficult, but it will be time consuming.

Another will be to add an option to play the game in chapter-length form, i.e., in a format shorter than the six-session condensed schedule that currently exists.

In the summer of 2018, I plan to attend the RTTP Game Development Conference, to further play-test the game and get feedback from other experienced RTTP game developers.

Also in the long term, I will be reading in more depth about each of the characters in the game. These readings will allow me to add more detail and "character" to the roles.

Reporting and Publishing Plans

I plan to submit a paper regarding this work to the 2018 SIGCSE Symposium. If this paper is not accepted, I will take the reviewers feedback into consideration and re-submit to the 2019 Symposium, or to another appropriate ACM conference. I will also submit a paper regarding the work to the regional Midwest Instruction and Computing Symposium (MICS 2018).

The RTTP consortium has a five-level game development process:

1. Concept
2. Prototype
3. Posted to Game Library
4. Ready to Publish
5. Published

The game is currently is the concept stage. At the start of the fall semester, I will submit the prototype game materials, which should move the game to the prototype stage. At that point, the game materials will be available from me for anyone who wants to try the game in their classes.

After the fall semester, I will update the game materials to reflect the lessons learned. After that, once the core texts section is complete, I will re-submit the materials, hopefully moving the game up to the "posted go game library" phase. At that point, the materials to play the game will be available from the RTTP Web site. I hope to have the game listed in the STEM-related sub-listing of games, as well.

My long term goal is to have the game published by the RTTP consortium. This will require several different instructors at different institutions to use the game in their classes, and quite a bit of editing. I am hopeful that the game is popular enough to make it to this level.

Conclusion

I wish to thank the ACM and SIGCSE for awarding me this grant. I have wanted to write a RTTP game regarding Charles Babbage and his calculating engines for several years, but have never had the time to do so. This grant provided the motivation and funds to get the process started, and for that I am very grateful.