CURRENT RESISTANCE™

Game Design Document

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I. Project Summary

Current Resistance™ is an online-accessible game and future downloadable mobile app that aims to teach players the basics of electronic color code. Using intuitive game mechanics, fast-paced click-and-drag actions, and leader-board-based competitive play, *Current Resistance*™ captures the learning game experience in a twitchy, cipher-recognition format. The game's overarching narrative pits the gamer in the role of survivor, who must use his or her limited knowledge of ohm's law, resistance, and current flow to keep a light bulb lit—in a desperate attempt to keep a horde of hungry monsters at bay. While the game's main premise aims to train learners how to recognize the values implied by the series of banded colors common to electronic components, namely resistors, it does not intend to teach users how to calculate the voltage, current, or resistance across a circuit. Instead, it means to utilize the inherent dramatic, emotional, and creative experiences that games foster in order to leverage meaningful and/or transformative play in the user—by forming emergent interests in the electronics and physics fields.

In summary, the game experience encompasses a broad range of tasks, spanning resource management and pattern recall, in order to create a fun, challenging learning environment for players, whether or not they intend to learn electronic code. During game play, the core game mechanic entails matching the correct banded resistor (or a combination of multiple resistors) with its ohm value. While each ohm challenge is timed, and players are penalized if they choose an incorrect component, the game is not meant to be severe, but rather, is meant to foster an understanding of electronic code by way of scaffolding (i.e. ramped difficulty mechanics) and trial-and-error play. Through

reflection, self-evaluation, and correction, players can learn from their mistakes, and experience ultimate pleasure through their eventual success.

I. a. Target Audience

Current Resistance™ is targeted towards two specific audiences: (1) gamers of all ages interested in puzzle-solving challenges, and (2) learners starting an entry-stage course in physics and/or electronics. The electronic color code is a basic shorthand branded on many electronic components, mainly resistors, so that values and ratings can be noted in brevity. For beginner-level electronics and physics students designing circuits, knowing this code is essential. Many of these courses are offered in high-school and college-level settings, where the students enrolled are often predominantly male and between the ages of 14 and 23. Due to the affinity for video games and science-fiction in this target population, it was essential to design a learning tool with these implicit tastes in mind.

I. b. Objectives

The goals of *Current Resistance*™ are, as noted, to (1) provide a fun and attractive atmosphere for both gamers and learners to engage with coding concepts in circuit-based physics, (2) to build an understanding of the electronic color code, whether that be through advanced honing or as an introductory preamble, (3) to challenge a player's resource and time management skills, and (4) to encourage transformative play,

whereby gamers can gain an appreciation or interest in electronics subject matter. It should be mentioned that, while some players may play *Current Resistance*™ mainly as an interactive diversion, it is this designer's hope that they will come away from it with a better understanding of resistor coding, electronics, and resource management.

I. c. Description of Content

The scope of material in *Current Resistance*™ is fundamental, with a focus on how colors are used to code for resistance values in the design of circuitry. In electronics, resistors are ubiquitous components, and used to reduce the voltage (V) and current (I) across a circuit, according to Ohm's Law:

$$I = \frac{V}{R}$$

While the equation above is not mentioned in the games story or rule documentation, the utility of resistance (R) is heavily implied. Without the proper resistors in place, the in-game light source will either overheat or fail to light, resulting in a player penalty—or, in more severe cases, the player-character's death. This simulates the real-world notion of precision engineering, whereby the proper resistance must be used to guarantee the fortitude and functionality of an electronic circuit. But, in order to do that, one must understand how to "decode" a resistor's value.

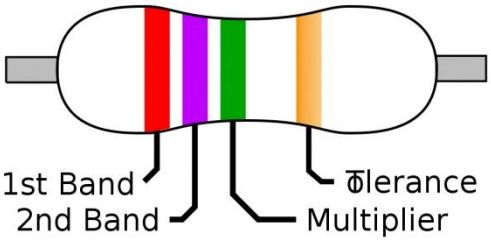
In resistors, the electronic color code is relatively straight-forward, and involves a one-to-one translation of color to number, be it for a conversion of the numeral itself

or a magnitude multiplier (as in the case of a resistor's second-to-last band). For further clarification, see both the following table and public domain image:

Figure 1. The electronic color code.

Color	Significant figures	Multiplier
Black	0	$\times 10^{0}$
Brown	1	$\times 10^{1}$
Red	2	$\times 10^{2}$
Orange	3	$\times 10^{3}$
Yellow	4	$\times 10^{4}$
Green	5	$\times 10^{5}$
Blue	6	$\times 10^{6}$
Violet	7	$\times 10^{7}$
Gray	8	$\times 10^{8}$
White	9	$\times 10^{9}$
Gold	–	$\times 10^{-1}$
Silver	–	$\times 10^{-2}$

A 2.7M Ohm Resistor



In *Current Resistance*™, players are challenged to decode the three bands on a selection of given resistors in order to match the required value given in the "challenge box." The tolerance band, which signifies the percentage that a single resistor's value may vary, was removed for simplicity's sake, as it may confuse players unfamiliar with the system. In harder levels (i.e. once players have made it past a certain total survival time), players are challenged to combine two resistors in a series, and in so doing, learn the value of combined resistance (i.e. 100Ω + 50Ω = 150Ω). But this, and other progressively more complex skills, are added in a "ramped" manner, as to provide the proper scaffolding for comfortable learning.

I. d. Market Analysis

In an assessment of the market, there is little to be said for video games designed to teach the electronic color code system. Many of the interactive applications available are not true games, but rather, online websites or mobile applications built to act as resources for quick reference. For example, Nick Reeder's *Color-Code Challenge*,[1] Patrick Hoppe's *Resistor Color Code Practice*,[2] and delboy22's *Resistor Colour Code*[3] are all HTML-based tools meant to test one's knowledge of the coding system. But, at their core, they are more a testament to self-assessment (quizzes and clickable diagrams) than anything close to a game. Likewise, Nathan Powelson's *Resistor Color Code*,[4] Yukon UA's *Resistor Color Code*,[5] and Jose Antonio Tirado Dominguez *Resistor Color Code*[6] are mobile applications designed as fast-access translators—but as games, here too there is much to be desired. So far, there are no narrative-based interactive challenges available that use resistors as a main focus of a given game. In that way, *Current Resistance*™ is without doubt a certain novelty.

II. Design Description

The overall concept for *Current Resistance*™ was to create a fast-paced puzzle-solving game that exercised the notion of symbol recognition and interpretation. In this

[1] Nick Reeder's *Color-Code Challenge*: http://people.sinclair.edu/nickreeder/Flash/colorCode.htm

[2] Patrick Hoppe's *Resistor Color Code Practice*: http://www.wisc-online.com/Objects/ViewObject.aspx?ID=DCE1002

[3] Delboy22's *Resistor Colour Code*: http://www.funtrivia.com/playquiz/quiz2664721e821c8.html

[4] Nathan Powelson's *Resistor Color Code*: https://itunes.apple.com/us/app/resistor-color-code/id322001850?mt=8

[5] Yukon UA's *Resistor Color Code*: http://www.windowsphone.com/en-us/store/app/resistor-color-code/

[6] Jose Antonio Tirado Dominquez's *Resistor Color Code*: https://play.google.com/store/apps/details?id=jatd.rcc

case, the symbols were colors and the interpretation was resistance value. In order to make this concept palatable, it was important to devise a simulated scenario where such a mechanic would prove vital to survival, and in turn put quick analysis and action into context. With the intended audience firmly in mind, the following immersive first-person storyline was developed:

> *"It is the year 2088, and you are the sole survivor of a resistance force fighting to outlive a horde of monsters that has shrouded the Earth in darkness. In order to survive, you have made a makeshift light source to keep the creatures at bay. But, in order to keep it lit, you must choose the appropriate electronic components, called resistors, to manage the constantly fluctuating current. You know nothing about electronics, but have a found document labeled "CODES." You wonder if reading it might help you stay alive..."*

This narrative was meant to keep the task relevant to the player, giving them incentive to play, and putting them directly into the action; *they* are the one who needs to survive. From here, the design grew organically, with the core mechanic being the process of choosing the correct resistor to fit the ever-changing current of the light bulb. This was designed as an easy-to-understand drag-and-drop process. In order to create a sense of challenge, a "challenge timer" was added to encourage the player to make a decision quickly. A fast, accurate selection was rewarded (in points equaling the remaining seconds on the clock, as well as additional survival points), and a poor or slow selection was cause for penalty (a loss of survival points or death, respectively). Finally, in order to give players a crutch for survival, an accessible electronic code chart was available for viewing, at the expense of time. The game was designed as a contest of survival, where lasting longer durations of time heightened the challenge, in this case by removing visual crutches or adding more difficult ohm-based problems (like combined resistance, etc.).

II. a. Platform

Current Resistance™ is intended to be an online browser game, with accessibility geared towards future mobile applications. Because the game's competitive play is based on the inclusion of a leader board, a broad community is important to keep players engaged and actively attempting to one-up each other's survival times. The addition of touch-based and mobile accessibility is desired not only because of the prevalence of such devices, but also because the drag-and-drop design lends itself to touch-pad game play. Additionally, because *Current Resistance*™ tends towards relatively short game play sessions, it fits the mobile framework nicely.

II. b. Aesthetic Design

Current Resistance™ was primarily designed with a population of electronics students in mind, and so the proper aesthetic had to be implemented. As such, players would be mainly high-school and college-level students, primarily male, and between the ages of 14 and 23. As previously mentioned, video games and science-fiction tend to be popular among members of this community, and so the art-style used was drawn heavily from existing related media. The tone is gritty, offering a moody and desolate atmosphere. In many ways, it parallels the narrative implied, offering a sense of dread that also heightens the player's emotional connection to the task at hand; urgency. Artifacts alluding to the story—like old papers, frayed wires, and makeshift circuitry—enhance the immersion factor. De-saturated colors and silhouettes were used to push irrelevant details to the background, while highly saturated, bright reddish hues were used to call out important

aspects of the GUI, like the timer, resistors, and "challenge box." The colors on the banded resistors were emphasized and left highly saturated, in order to make them distinguishable to the player, especially since they are a core element to game play. And finally, in order to indicate whether a player's move was correct or incorrect, minor animated details (i.e. an electric shock, flickering bulb, etc.) and sounds were also employed.

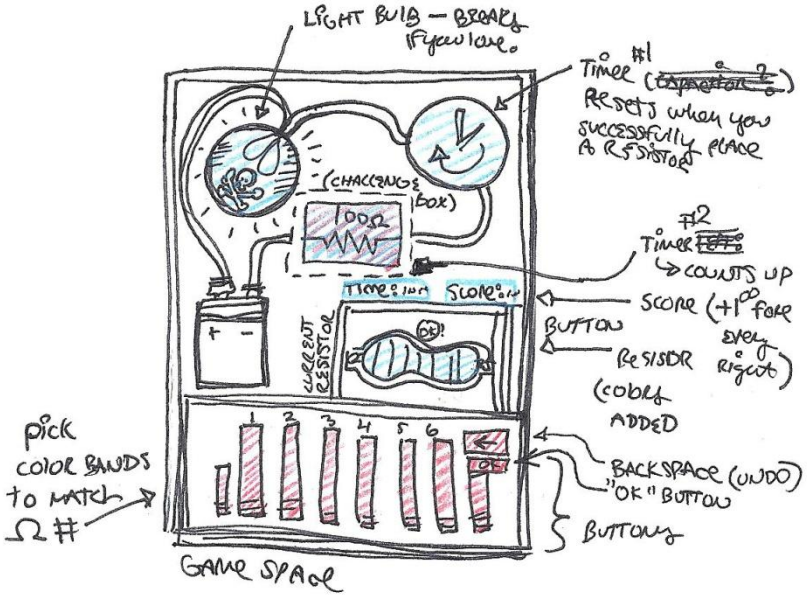
II. c. Game Mechanics

Generally, the core game mechanics of *Current Resistance*™, as we know them now, boil down into three distinct levels of interactivity: cognitive, functional, and explicit. Cognitively, the "imaginative interaction" a player has while immersed in the gaming world is personal; the user *is* the hero, and so, they form an imaginary bond with the fictional world the game presents. While players understand that the game itself is illusory, the notion that they themselves are faced with a scenario is enough to create a cognitive mechanic in-game. Functionally though, *Current Resistance*™ takes on far more concrete operations.

To start, the player "clicks" to proceed through the title screen, story, and/or game over screens. Once the main playfield is activated, he or she has a number of choices to make: (1) he/she can click, drag, and drop a resistor of his choice into the "challenge box" in the top left of the screen, (2) he/she can pull up the "Codes" document by clicking on the "star icon" to review the electronic code cheat sheet, (3) he/she can hide the electronic code cheat sheet (when displayed) by clicking on the

document, or (4) he/she can combine two resistors in a series before submitting them to the "challenge box" by moving them to the "combo bin" (added to the GUI in later levels). With each interaction, a proper response by the game is administered. For example, if the wrong resistor (or resistor combo) is placed in the "challenge box" (displaying a given ohm value), the light bulb will flicker, a sound will indicate the error, and points will be deducted from the player's "survival points" total. See the Figure 2 for an early draft wire-frame of these player mechanics:

Figure 2. An early wireframe diagram of the playfield.



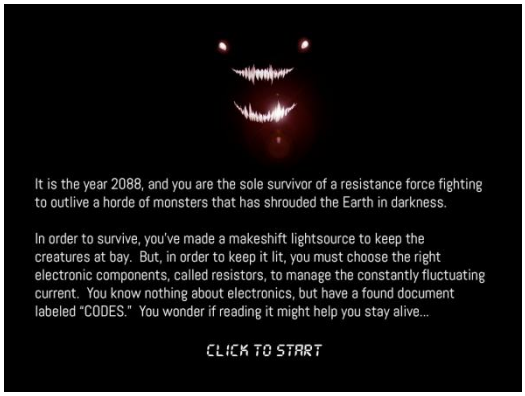
While early drafts of the design favored a 'keyboard-band-selection" mechanic over the "full-resistor-selection" one currently in use, the explicit results are the same: a player's choices result from action, and the 'randomness' of those choices—especially under the pressure of time—will ultimately build the player's experience. For a complete summary on

this and other elements relating to player experience, please proceed to following section for further reading (**II d. Player Experience**).

In the summation of mechanics, it is important to cover the interactivity afforded by the end-game leader-boards, which display the top total "survival times" played. Competitive play is very much a driving force behind many games, and a puzzle game of this design is no exception. With a board displaying the top survival times, a community can be built, competitive rivalries based on expertise can be formed, and interactivity beyond the realm of the game itself can ultimately be realized.

II. d. Player Experience

The player experience in *Current Resistance*™ begins with the title screen. After the logo is revealed, and a few seconds of atmospheric music is played, a prompt signals the player to click, initiating the story screen to appear. Casual fades and black-outs make for a smooth, fluid transition between screens. On the story screen, the game's main narrative is shown (see section **II. Design Description** for full text excerpt). After a few more seconds, a second message appears, prompting the player to "Click to Start." Once the player clicks, they are transferred to the main game play area, where a brief "Ready, Go!" overlay signals the start of a game session. Though players may not have any

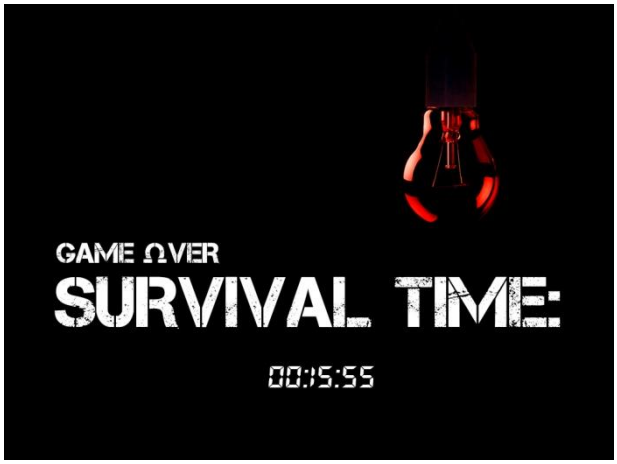


prior knowledge about the electronic color code system, or how to play the game, the back story hints at reading a "Codes" document, which can be accessed by clicking the star button at the bottom of the screen. When the star button is clicked, the electronic code chart scrolls up from the bottom for viewing. Although this "cheat sheet" covers the player's view of available resistors in the tray, it allows the player to become familiar with what each color means—at the expense of time. Granted, the first "ohm challenge" is meant to be easy, letting the player get a grasp for simple color-coding before the game challenges them further.

While the novice player attempts to make heads-or-tails of the challenge at hand, a timer in the upper right hand corner of the screen indicates how much time is left before the bulb at center burns out, ending his or her game. With each successful "ohm challenge," the timer is reset (to somewhere between 15 and 25 seconds), and players will again have to solve a new puzzle. Each puzzle (i.e. solvable ohm value) is displayed in the upper left-hand corner of the screen, here termed the "challenge box." When the player drags and drops the correctly banded correlating resistor into this box, he or

her is rewarded with a number of survival points equal to the seconds left on the clock, as well as a new challenge. (Note: success is also implied by a telling sound and an animated surge of electricity). If the player chooses an incorrect resistor, he or she is penalized with a subtraction of points from the survival points counter (and the light bulb at center will flicker ominously). If the survival point counter reaches zero, or the timer in the upper-right corner of the screen reaches zero, the game ends.

Scaffolding tactics built into the game ensure that the learning curve for the material isn't too challenging to overcome. In the beginning of the game, numbers are shown above the resistor bands to indicate their value. Once players reach a certain score-level, this crutch disappears, leaving players to fend for themselves. Selecting the right resistor also becomes more difficult as values move from two-banded to three-banded resistors. Additionally, once combination resistors are in play, it becomes a challenge to add the values of two resistors in order to get the required amount—and, in cases where "combos" are implemented, additional points are given in reward.



If a player exhausts the survival point counter or the challenge timer runs out, he/she is transported to the game-over screen, where his/her final survival time is displayed. The survival time indicates how long the player lasted in play, as indicated by the notepad tally in the bottom right of the game play screen. From here, this score is sent to the leader-boards, where it is displayed with other high-ranking scores. From here, if the player clicks again, he or she is returned to the title screen.

II. e. Incentives

The player's incentives can vary depending on the reasons for playing. From a learning standpoint, students who are looking to hone their skills may find pleasure in being able to recognize patterns and, in turn, responding to them quickly. In game, the overarching incentive is to stay 'alive' as long as possible, and in so doing, enables the player to brag about their achievements in online leader-boards. As in many games, community-based rivalries can give players a "goal to aim for." And, in the case of *Current Resistance*™ it is one beyond the realm of the main learning objectives.

Within the act of play, there are smaller nuances that can act as motivation to continue playing. The emotional connection (mentioned earlier) forms a bond between the player and his/her in-game self, making success meaningful to each user. Likewise, the tiered difficulty levels added with each milestone score (i.e. the removal of numbers or the addition of combo resistors) act as a kind of surprise, making gamers question "what's next" when they reach a certain score. In terms of each successful move, animated sparks and rewarding sounds are meant to signal triumph. When this pattern becomes realized and recognized by a user, it may very well be pleasing for a gamer to see and hear.

III. Theory of Change

The objective of *Current Resistance*™, as indicated, is to give students of physics and electronics a fun, interactive experience that will both introduce them to the concept of

electronic code and instill a transformative sense of interest in players. Over the long term, the game is intended to accomplish the goal of memory recall by giving players repeated practice on what each color means, and globally, how these symbols affect the construction of a smoothly working circuit. The results of playing *Current Resistance*™ may vary, and may take multiple play-sessions to achieve, but, with the motivating strategies, incentives, and polished game play offered herein, we as designers are confident that this end ultimately can be achieved.

Learning theorists—those that delve deep into philosophies regarding human cognition—provide us with a blueprint of how individuals acquires knowledge. Those that are constructivists, like Jean Piaget, believe that learners *build* upon previous experiences in order to interpret the meaning of information through the scope of their own understanding (Smith & Ragan, 1999, pg. 19). In the case of *Current Resistance*™, players build upon knowledge through repeated trial-and-error, grasping ideas about color and resistance as each challenge is met within context. This, additionally, can also be supported by those "situated learning" environments later described by theorists Lave and Wegner (1991).

Equally, constructionism, a theory devised by Seymour Papert, describes how learners create mental models and build upon them, drawing conclusions on their own cognitive structures (Ackermann, 2004, p. 6). In *Current Resistance*™, this too is realized, in that the game itself becomes an "object-to-think-with," and learners build knowledge by way of completing simplified circuits (Papert and Harel, 1991). While at its heart this application is undoubtedly a game, it is built upon sound reasoning in learning theory. And this, along with alluring game play, is intended to make for lasting change.

Game Credits:

Concept/Story: Matt Cirigliano

Design: Matt Cirigliano
Adam Gashlin
Gabrielle Moore

Programming: Adam Gashlin

Wireframes/Artwork: Matt Cirigliano

Rules Documentation: Gabrielle Moore

RESOURCES

Ackermann, E. (2004). Constructing knowledge and transforming the world. *A learning zone of one's own: Sharing representations and flow in collaborative learning environments*, *1*, 15-37.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation* (pp. 76-92). Cambridge university press.

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