

Trebuchet Attack:  
A Game of Simple Physics and Mathematical Relationships for  
Primary School Children



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Michigan is at or below the national average in math and science among 4<sup>th</sup> grade students (NAEP, 2008). Because of the cumulative nature of mathematics and science education, this deficit in early education in analytical thought shortchanges students in any future technical pursuits. Additionally public schools in Michigan are underfunded and having to compete with private and charter institutions which do not have to meet the same strict standards yet receive government funding. In order to remain viable in the increasingly competitive “education market” public schools are going to have to take an increasingly proactive approach to education while remaining fiscally conservative. To meet the needs of not only the increasingly demanding education market, but also adequately prepare students for the global marketplace non-traditional methods are going to have to be utilized in order to make learning both fun and functional.

Games accomplish this goal exceptionally well by presenting educational information in a format that engages the learner in ways that move beyond the abilities of traditional classroom education. Part of the draw of using games to accomplish the goals of education, is that they are very effective in achieving “Flow” and subsequently improving retention and cognition of the material being presented (Csikszentmehályi, 1990).

Trebuchet Attack serves just this purpose by allowing students to experience the raw power of physics and mechanics in a simple and understandable manner. Learning the mechanics behind a trebuchet is no different than learning the mechanics of other simple machines, but provides a much more rich illustration of the potential that simple machines have to alter the world around them. Trebuchets served as one of the most powerful siege weapons for nearly 1500 years and were only displaced by the advent of gunpowder. The relationship between the weight of the counterweight of the trebuchet and the weight of it's projectile is easily understood and acts much like a traditional level, but on a much grander scale. Most importantly, Trebuchet Attack introduces the basic mechanics and relationships between mass, weight, velocity and distance, laying the groundwork for a wide range of future technical learning and investigation.

Trebuchets have been used in education, but never in the form of an educational game and have been the subject of an episode of the PBS program Nova. The LEGO company offers teacher instruction for the use of trebuchets with the MINDSTORMS NXT system for physics curriculum, however most existing educational material focuses on late middle and high school students. Introducing trebuchets as an example of a simple machine at a much earlier age will prepare students for future curriculum.

Trebuchet attack is designed with public schools in mind. It is a web based, CSS application which simulates the trial and error process of adjusting a real trebuchet to hit a target. The game features exciting graphics and historically accurate element design to add depth to the experience and provide tangential learning opportunities outside the realm of pure science or math instruction. Because Trebuchet Attack is a web-based game, costs are relatively low to run and maintain the game, plus server-side user tracking and leaderboards are much easier to implement.

The basic game mechanics behind Trebuchet Attack find their roots deep in the history of video games. At its heart Trebuchet Attack is an artillery game, much like Gorilla or Scorched Earth. The player adjusts values for weight of the counterweight and the weight of the projectile to hit a castle at a variable distance. A heavier counterweight will throw the projectile farther, and a lighter projectile will travel farther with less counterweight. The challenge of the game is in adjusting the two weights through trial and error to hit the target with a projectile heavy enough to damage the wall. Player action is guided by a pedagogical agent in the form of a medieval man-at-arms who explains the principals of the trebuchet to the player and suggests corrections to the different weights.

To increase the tangential value of the game, the art of Trebuchet Attack will be very realistic. The pedagogical agent will wear period clothing and castles will be designed with actual castle design in mind. This design decision not only reduces the amount of original design that must be done, it grounds the game in reality and provides a deeper tapestry upon which to build the game experience.

The fun factor of Trebuchet Attack can also be increased by introducing competition, class,

school, or global leaderboards can be easily introduced based on a player's overall accuracy and efficiency. The online nature of the game lends itself well to hosted leaderboards, which can be highly customizable in their scope by either game masters or a central server. By encouraging students to compete with each other to better their overall percentage scores, total playtime will be increased as students attempt to overcome their early low percentage as they learn the mechanics of the game. This increased play will also increase uptake of the information being presented.

Trebuchet Attack has a strong base in theories of both education and game design. The pedagogical agent acts as a conduit for the will of the game designer while facilitating engagement and appropriate social interactions (Kim & Baylor, 2006). Portnow's ideas of tangential learning add to the strength of the environments within the game and open the door to additional information acquisition and improved flow establishment (Portnow, 2008). The most important design principal utilized in Trebuchet Attack will be that of designing for fun. The foremost design goal of the game will be fun in order to ensure that the desired flow state is reached in make sure that the game is successful in it's educational goals. To this end, the game mechanics of Trebuchet Attack will be the primary design consideration. Making a game centered on an addictive and fun mechanic will provide an excellent jumping off point for the acquisition of knowledge.

The use of open source software and programming languages like CSS will serve to severely limit the cost of production of Trebuchet Attack. Table 1 shows expenses for production and hosting of final content. The addition of an iPhone developer license would allow the ability to publish the game as an iPhone app as well as in online format.

Aperture 2 Photo Editing Suite	\$200.00
iMac Development Computer	\$1,500.00
iWork Productivity Suite	\$80.00
VMWare Fusion	\$80.00
Web and Application Hosting	\$500.00
(1x) Programmer	\$2,000.00
(1x) Content Expert	\$2,000.00
iPhone Standard Developer Program	\$100.00
TOTAL	\$6,460.00

*Table 1*

Trebuchet Attack would take 14 months to bring to completion. The background work in establishing the mathematics behind the trebuchet has been well established by the work of Donald B. Siano (Siano, 2001), and the random nature of the levels, and simple story will require little time to bring to completion. Initial planning and concept design will take roughly 6 months. In this time scripts would be completed, characters and locations will be designed and the trebuchet engine would be designed. The primary programming phase of the project will take a further 6 months with multiple revisions of the software and graphics. Final playtesting will take place for 4 weeks and initial evaluation testing will occur immediately thereafter for 4 weeks. Evaluation testing will be comprised of double blind tests with and age-appropriate test and control group. Subjects would take a pre-test, then play the game, then take a post test to determine the effectiveness of the game in accurately conveying knowledge. At the end of the evaluation period the game would be offered to schools via digital download with multiple licensing models available. Depending on the level of funding received, licensing may be free, provided that no costs have to be recouped. If schools choose to have the game remotely hosted by the developer, a yearly cost will be incurred to cover the annual operational costs of the game.

## Appendix I: Screen Shots

*Fig. 1: Splash Screen*



*Fig. 2: Projectile and Counterweight Settings Screen*



*Fig. 3: A Miss!*



## Sources

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