

Everything I Ever Needed to Know about Simulation and Training I Learned from Ender's Game

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ABSTRACT

The novel *Ender's Game*, while a work of fiction, presents a fascinating case study in how modeling and simulation can be applied for both individual and collective training. In addition, *Ender's Game* is a great text, and practically required reading, for modeling and simulation professionals. Ender Wiggin, the fictional hero of Orson Scott Card's *Ender's Game*, knew the value of simulation in the realm of training as well as anyone. Time and time again during his training regimen, he utilized simulations to test himself and his team up to, and at times beyond, their breaking points. Ultimately, the learning environment in their schoolhouse provided Ender and his team the tools for success. This paper will explore lessons learned from Ender's use of simulation to train individually and as a team, and review *Ender's Game* as a modeling and simulation case study. (Naturally, this paper contains spoilers about the novel).

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INTRODUCTION

Fictional novels seldom serve as inspirational works from which experts can draw. The art of great storytelling typically does not win out over the research needed to ensure the representation of scientific or historical fact. Occasionally, however, a work of fiction breaks the mold and holds lessons for even those well versed in a particular industry. *Ender's Game* is such a novel.

Orson Scott Card originally published *Ender's Game* as a short story in 1977, then released it as a full novel in 1985. It has continued to enjoy commercial success, ranking as the top-selling science fiction novel as recently as 2012 (Habash, 2013). A motion picture, released in 2013, performed well in box office sales out of the gate, holding the top spot the first week of its run (The Numbers, n.d.).

The novel centers on young Andrew "Ender" Wiggin, a third child in a future society in which parents are typically allowed only two children. As a very young child, he is tested and found to be a promising candidate for Battle School, an off-planet training site designed to train children and teens in the science of war and the art of leadership, or as the character Colonel Graff states it, "for training future starship captains and commodores of flotillas and admirals of the fleet" (Card, 1991, p. 20) (Note: references to *Ender's Game* are from the 1991 Tor paperback edition.) Battle School served as a sort of School for Command Preparation, War College, Surface Warfare Officers School, and elementary-through-high school all combined into one. Such training is necessary to prepare Earth's fleet for an invasion from the "Formics," a mysterious alien race that has invaded the solar system twice and is approaching a third time.

While much of *Ender's Game* focuses on Ender's state of mind during his Battle School time, and the post-Cold War balance of power on Earth, the use of simulation to enhance training is a theme, even if an accidental one, throughout the novel. *Ender's Game* provides powerful lessons in how simulation can enhance training, and it can serve as a great text for an introduction to modeling and simulation for training.

A Brief Introduction to the Simulations in Battle School

Upon Ender's arrival to Battle School, he and the other children are inundated with a challenging curriculum of simulation-based training courses. The courses are designed to harness the limitless creativity of children and channel that creativity to mold them into Earth's greatest soldiers, tacticians, and leaders in order to destroy the Formics. To accomplish this, the simulations in Battle School are arranged into individual and collective modalities.

Using virtual training environments, the children go head-to-head on an individual level against computers that simulate Formic battle tactics to gain the knowledge and abilities required to defeat the enemy. The children can then compete against one another in the virtual environments to further develop their strategies. The next phase involves live collective training. Divided into armies, the soldiers must learn to function as a single unit to accomplish a mission objective in the battleroom. With enough skill, soldiers can become commanders of their armies and must learn to lead them effectively. By merging these individual and collective training components, the soldiers' knowledge, skills, and abilities can translate into operational readiness.

ENDER IN BATTLE SCHOOL

Ender was six when he was taken from Earth and brought to Battle School. Early in the story, he meets Colonel Graff, the Director of Primary Training at Battle School. Graff comes to Earth to escort Ender to Battle School. Ender quickly adapts to Battle School, and spends a fair amount of time playing, and losing, a virtual game. Soon, in fact sooner than most, he is put in an “army” to compete in the battleroom, a zero-gravity laser-tag environment, to learn tactics. Major Anderson is in charge of the battleroom games. Anderson and Graff discuss Ender’s progression and well-being as a preface to each chapter.

Ender becomes quite successful in the battleroom, and earns command of his own army, again far earlier than most. Along the way, he makes enemies, but he also makes friends. He files away lessons learned, not only from good commanders, but also from bad ones. After four years, at age 10, Ender is graduated from Battle School to Command School. At Command School, he continues his preparation, mentored by Mazer Rackham, a hero from the first Formic invasion. Other characters he has worked well with along the way are also brought to Command School. The focus at Command School switches from a live tactical view to a constructive strategic view, as Ender and his cohorts command spaceships and ultimately fleets, fighting against an adaptive opponent that simulates the Formic fleet.

Individual Training

Ender’s first use of modeling and simulation in Battle School is in a game room on his second day. As the smallest kid in the room, he is forced to watch others play games more than play himself. Ultimately, he realizes that most of the other students learn games by playing against a computer opponent, thus adapting to the computer’s tactics and attempting to use these tactics against other human players. Ender uses this knowledge to defeat older players in the game: he first plays as the computer would, detects how his opponent plays, and then adapts to his opponent’s style, defeating him soundly.

Ender also plays a virtual game on his personal computer (his “desk”) in which he must defeat a giant in order to move to the next level. As Anderson and Graff discuss his progress, it is evident that this game, unlike the game in the game room, has an adaptive opponent. Ender is continually defeated, but he persists. Finally he “cheats” the game by killing, rather than outwitting, the giant, somewhat similar to how James Kirk cheated the Kobayashi Maru simulator in Star Trek (Anonymous, n.d.).

Finally, Ender and the other newcomers to Battle School are also given access to a zero-gravity room where they can practice for the games, the live training, laser tag-like, force-on-force simulation that most typifies the training at Battle School.

Collective Training under Others

Under an Aggressor

Just before his seventh birthday, Ender is selected to become a soldier in Salamander army with some of the older children. He is placed under the command of Bonzo Madrid, a hotheaded commander with an aggressive leadership style. Bonzo is furious that Ender, a six-year-old with zero experience, has been assigned to him just as he is trying to move his army up in the rankings. He forces Ender to stay out of the way, and never to draw fire during battle.

Bonzo’s decision, in turn, forces Ender to observe. He makes careful note of Bonzo’s strategies during team practice sessions, and analyzes every formation and movement to determine its weaknesses. From this, Ender begins to develop counter-strategies for how an army could conquer Salamander. He realizes that one of Salamander’s greatest weaknesses is Bonzo’s authoritarian leadership style – instead of building up his soldiers and making them want to improve, he abuses them physically and psychologically. Bonzo also fails to communicate – he speaks and gives orders, but anyone who offers a different perspective is fiercely chewed out or smacked.

Under a Friend

Yet despite Bonzo’s faults as a leader, Ender recognizes after several battles that Salamander is a very effective army. From watching his comrades in training and in battle, he realizes how much he needs to improve the skills he has and establish a wide variety of other skills he lacks completely. He befriends Petra Arkanian, a sharp shooter who offers Ender her tutelage during free time so that he can master his fighting abilities and develop new skillsets. Petra shows

Ender how to shoot, and how to navigate the battleroom without running into obstacles. He soon blends his ideas with his skills during a battle and draws fire against several soldiers at a key moment during the game, against Bonzo's orders, and manages to rescue Salamander from a near-loss.

Under a Supporter

Ender's loss-preventing strategy earns him respect from the other armies. He is traded out from Salamander into Rat army at the request of Rat's platoon leader, Dink Meeker. Dink recognizes Ender's potential: he encourages Ender to demonstrate his ideas so that he can incorporate them into his platoon's strategy, and he allows him to work collectively with other soldiers in the Battle School to develop and test new techniques. He tests a new technique in a battle with Centipede army where he immediately launches himself feet-first towards the enemy's gate – the zero-gravity environment allows Ender to orient his body so that the enemy's gate is down. It leaves no time for the enemy to assess the battleroom before making a move and it makes his body a much smaller target to hit. The effects are devastating: Ender singlehandedly decimates over a dozen Centipede soldiers before his flash suit is immobilized. Dink trains his entire platoon to adopt this strategy, and Rat army rapidly climbs the rankings. Ender's tactic is so effective that every other army is forced to change their formations – as Card phrased it, “the game had changed.”

Under a Master

Just as Ender is shifting the paradigm of battle, Card reveals to the reader the true nature of the games. Colonel Graff is masterfully commanding the entire Battle School as one, large collective training session. He closely observes Ender and his strategies. He convinces Major Anderson to help him change the entire program so that it pushes the boundaries of Ender's genius as a tactician and his strength as a leader. Graff knows that the International Fleet will soon arrive at the Formic home worlds, and these students will have to complete the mission at hand under Ender's command. He is working as rapidly as he can to prepare these soldiers for battle, with Ender as their leader. Before he can accomplish this, however, he must assemble Ender an army of his own.

Collective Training as a Leader

After three years as a soldier in Salamander and Rat armies, Ender is given command of his own army, some one-and-a-half years early, according to Major Anderson. Dragon Army was created specifically for Ender, a brand-new army for a first-time commander. Battle School leadership assigned students with little or no experience to Ender; when he first saw his youngest soldiers, he realized how he looked to Bonzo Madrid when he was first assigned to Salamander Army. Ender took advantage immediately of time allotted for practice by getting his army to a battleroom and observing their performance. In Ender's view, success in the battleroom was the goal of Battle School; all else was secondary. As such, he wanted to immediately gauge his troops' performance and give his instruction based on their performance. This differs sharply from the “crawl/walk/run” training concept in which classroom instruction is followed by instructor-led, hands-on training often using part-task trainers, with collective training in a fully simulated live environment as a final capstone exercise. Ender's approach would be akin to taking new Marine recruits directly off the bus at Parris Island and leading them to the Crucible. As his inexperienced army floundered in the new battleroom environment, Ender took note of particular strengths and weaknesses of individual soldiers. From this experience, Ender soon found himself in a mentor/protégé relationship with Bean, who quickly became his most-trusted platoon leader.

More importantly than Dragon Army's development, Card documented how Ender used these collective training sessions as a way to develop himself as a leader. Ender learned from both good and bad leaders, from strict disciplinarians to more lax commanders. He applied these lessons to the soldiers in his army, using simulation environments as the arena in which to impart real-world lessons learned from his experiences. When his inexperienced soldiers complained a training session had them practicing maneuvers and not combat, Ender replied, “There's no combat without movement.” Clearly Ender understood the value the simulated environment offered to hone his soldiers' individual skills, his army's collective skills, and his own personal leadership skills.

LESSONS LEARNED FROM ENDER'S EXPERIENCES

Lesson One – The Training Spectrum Ranges from Individual to Collective

All military services train the individual before they train the unit. Ender's time in Battle School was no different. All newcomers (“launchies”) to the school were subjected to classroom instruction and virtual simulations before they

were assigned to an army. Once assigned to an army, their platoon leaders worked with them in small units prior to allowing them in the battleroom. Ender, by necessity, put this spectrum aside when training Dragon Army. He was forced to train his army to perform as one team immediately. Individual training became more experienced soldiers taking on the less experienced and instructing them one-on-one, under Ender's guidance.

Lesson Two – All But War is Simulation

Army Doctrine Reference Publication 7-1, Training Units and Developing Leaders (U.S. Army, 2012) lists several principles of Army unit training. One is “Train as you will fight” (p. 2-1). A similar concept is codified in the former logo of the U.S. Army's Program Executive Office for Simulation, Training, and Instrumentation (PEO STRI): “All But War is Simulation.”

As Dragon Army's leader, Ender embraced these concepts. His training sessions enforced primary concepts such as maneuver and marksmanship that he knew were crucial in the battleroom's games. Ender was trained to view these games as war. In the end, even war was simulation, as Ender and his commanders did not realize their final battle was real force-on-force, and not a simulation.

Lesson Three – Perception of Limitations

The training program at the Battle School was very challenging. Yet, critically, it was designed such that the children could challenge the training program itself. Indeed, they had to in order to succeed – success was defined as “winning at all costs,” with besting the simulation or others in the simulated environment as the sole prize. Ender did this on multiple occasions throughout the novel.

In the mind game involving the giant, the player appears to be faced with failure; by design, neither of the options led to a successful conclusion. As part of the training program, Colonel Graff and Major Anderson sought to discover how Ender would deal with the prospect of imminent failure. By killing the giant instead of accepting one of its choices, Ender refused to be limited by failure. This was further confirmation to Graff and Anderson that their search for a brilliant leader was over.

From then on, Ender develops a habit of challenging perceptions in order to complete his mission – to win at all costs. In the battleroom, he takes full advantage of the zero gravity environment and alters his body position with his feet towards his enemy, simultaneously shrinking his body's profile as a target while still allowing him to direct fire. Ender incorporates this strategy into his battle formations. Dragon Army would regularly sacrifice its soldiers as human shields, but this was the price for victory – all other considerations beyond meeting that objective were secondary.

Finally, Card addresses the consequences of the perception of limitations that simulation affords. During command school, Graff and Rackham convinced Ender he was completing a final battery of simulations that Rackham had designed; in Ender's mind, since Rackham architected the advanced Formic simulations, his challenge was to beat Rackham. Rackham and Graff knew that simulations allowed trainees to separate their actions from the consequences of those actions. They knew that by disguising Ender's mission as a simulation, he would not be distracted by the real consequences, thereby maximizing his focus on destroying the enemy.

Ender's freedom from consequence and his need to win at all costs directs him to use the molecular distortion device against the Formics, obliterating their home world and nearly rendering them extinct. Only in the aftermath of his victory does Ender realize that the consequences are real, and it causes him incredible distress. With this plot twist, *Ender's Game* provides excellent commentary on the moral and ethical questions that simulation poses.

Lesson Four – OPFOR Must Adapt

Early in his time at Battle School, Ender noticed older students playing 3-D games. Since he was still a “launchie” he could not play the game, so he learned by watching others play. He discovered the older students often learned by playing against Artificial Intelligence (AI) opponents. The AI was not adaptive, and resulted in human players becoming predictive as opponents – accustomed to playing a static OPposing FORce (OPFOR). They employed only the tactics and strategies required to defeat the AI OPFOR regardless of whether they played against AI or human opponents. Ender used this knowledge against his opponents: he knew how they would react because he knew how

the AI would force them to react. Resolving the issue of non-adaptive, static, AI is not science fiction, however. “A major disadvantage of non-adaptive game AI is that once a weakness is discovered, nothing stops the human player from exploiting the discovery” (Bakkes, Spronck, & van den Herik, 2009, p. 28). Bakkes, Spronck, and van den Herik proposed a concept known as *opponent modelling* as a framework for machine learning algorithms to develop “case-based adaptive game AI” (p. 28). Had the virtual game been blessed with such a dynamic, adaptive AI OPFOR, Ender may well have faced much tougher human opponents, as they would have been forced to adapt their own game to beat the computer.

Card did insert adaptive technology into one game Ender played during his free time. He faced a giant that always defeated Ender until Ender decided to take a more drastic approach and kill the giant. Later, the game adapted in a way that not even Major Anderson and Colonel Graff expected. Later books hinted at a link between the Formic queen and the simulation environment.

Lesson Five – There is no “One Size Fits All” Training

Anderson’s and Graff’s conversations, which begin each chapter, offer insight into how Ender is progressing through Battle School. However, their conversation preceding chapter 4 is especially poignant. At the close of chapter 3, Ender has agreed to leave his family and go to Battle School. Anderson and Graff discuss his training regimen, and it is clear that Graff has a plan for how his training is to be structured based on data collected from Ender’s observed behaviors and mental patterns. While we are not at the point of embedding technology to read thoughts directly into students’ brains, we do have the capability of gauging the level of knowledge of incoming students via online pre-tests. Knowledge of an in-coming class’s strengths and weaknesses can then be used to tailor the courses (Pike & Hosni, 2004). As an example, assume Ender and his fellow “launchies” performed poorly on a pre-test on first aid fundamentals, but all pre-tested well in weapon familiarization. The weapon familiarization class could be shorted, and extra time allotted to first aid.

Lesson Six – Fully Blended Learning

In Anderson and Graff’s training regime, all of the separate learning elements inform one another. From the classroom environment, to the individual and collective simulations, and even the social interactions of the soldiers during their free time – in each instance, Ender’s behaviors are evaluated, and his performance influences his future learning experiences. Although the Battle School’s assessment system borders on Orwellian, it highlights two principles that can reasonably apply to real warfighters.

First, performance in one setting, such as a simulated training experience, should help inform future learning. Although straightforward, most contemporary training programs still treat each event as a stovepipe. At best, participants must complete pass/fail “gates” to progress, but rarely do the specifics of their past performance directly inform the nature of their future learning experiences.

Second, personnel should be assessed holistically in all learning experiences; classrooms are not the sole testbeds for declarative knowledge nor are live training evolutions the only place to evaluate applied tactics. Instead, the whole person is continuously tested in each context. Performance evaluation also extends to informal learning contexts, i.e., those learning events that take place outside of formally structured education or training settings. In *Ender’s Game*, comprehensive performance data from all of these diverse learning environments feeds into a unified learner profile. In the real world, new technologies, such as the Advanced Distributed Learning (ADL) Next Generation Learning Environment, are beginning to enable the capture and integration of disparate, formal and informal learning outcomes.

Lesson Seven – Emphasize Cognitive Readiness

Much of Ender’s training in Battle School is designed to provoke his critical thinking, adaptability, decision-making, and team performance skills. Although he and the other young soldiers also study tactics and procedures, they also spend significant time practicing the mental, emotional, and interpersonal skills needed for complex, uncertain future problems. In Card’s world, mankind faces an alien opponent who they cannot fully understand nor predict; hence, they need to develop independent reasoning, good judgment, and mental flexibility. Although less extreme, in our own world, our warfighters face greater volatility, uncertainty, complexity, and ambiguity; similarly, our personnel must develop the independent thinking, emotional regulation, and interaction skills necessary to cope with such

contexts. This cluster of skills is often referred to as “Cognitive Readiness,” and programs like the Marine Corps’ Small Unit Decision Making (SUDM, 2011) initiative or the Army’s efforts to advance the Human Dimension (U.S. Army Combined Arms Center, 2014) exemplify the focus on it.

ENDER’S GAME AS MODELING AND SIMULATION TEXT

While *Ender’s Game* is a work of science fiction, the modeling and simulation training tools adopted by Battle School, and their successful use by Ender, can be used as a classroom instruction adjunct. Classic themes in modeling and simulation for training resonate throughout the book, as do emerging themes. An instructor can develop any number of discussion questions suitable for a high school, undergraduate, or graduate class. The following subsections are intended to present ideas for modeling and simulation teachers who wish to use the book in class.

Domains

Modeling and simulation is categorized by domains: live, virtual, and constructive. The live domain involves real humans operating real systems, albeit not against a real enemy. Real people controlling simulated systems comprises the virtual domain. Simulated people controlling simulated systems is constructive. *Ender’s Game* featured all three domains. An easy discussion question would be to identify examples of each domain, and defend what makes each example a live, constructive, or virtual simulation. A more advanced question would involve defending the use of a particular domain for a particular training task, or at a particular point in Ender’s training curriculum.

Embedded Training

The Army Training Support Center defines embedded training as “training provided by capabilities built into or added onto operational systems” (ATSC, 2003, paragraph 1). Ender’s final training sessions on Eros, a remote base on the edge of our solar system, would be considered embedded training. At some point, the switch was flipped from training to operational status as Ender and crew destroyed the Formic fleet. Ender did not know until the battle was over that he had destroyed real, live, sentient beings, and ultimately made decisions that sent real, live, human beings to their deaths. Discussion questions could orient around the suspension of disbelief afforded by embedded training.

Computer Generated Forces

As mentioned earlier, the adaptability of the OPFOR, or opposing forces, in the various simulations differed greatly, from static to extremely (and unpredictably) adaptive. At no time during Ender’s stay at Battle School did the Computer Generated Forces (CGF) model expected Formic behavior – was this a concern or was Battle School intended to teach far more basic concepts that were to be honed on Eros?

WHAT DID CARD MISS?

Ender’s Game does not paint the perfect picture of how to employ modeling and simulation in a training program, however. There are elements of an effective training program that were not present in the book, and any use of the book in a classroom setting would be well served to identify these in detailed discussions

After Action Reviews

It is not clear that any of the army commanders or even platoon leaders held an after action review, or AAR, session following either training, practice, or game sessions. The military holds AARs after both training events and operational missions to give participants the opportunity to reflect on what went well and what needs improvement. The Army considers AARs so invaluable to a well-run training program that it has published doctrine on how to conduct them. *The Leader’s Guide to After-Action Reviews*, dated December 2013, is the latest policy documented. An interesting discussion scenario would be to put students in the roles of some of the various Battle School army commanders, including Ender, and have them plan and lead an AAR based on specific battles and training sessions from the book.

Resilience

Resilience has been defined as “the capacity to adapt successfully in the presence of risk and adversity” (Meredith et al., 2011.) The U. S. Army defines resilience as the “mental, physical, emotional, and behavioral ability to face and cope with adversity, adapt to change, recover, learn and grow from setbacks” (U. S. Army, n.d.) The Army further defines “ready” as the “ability to accomplish assigned tasks or missions through resilience, individual and collective team training, and leadership” (U. S. Army, n.d.). While Card discussed the use of simulation to enhance both collective and individual training, and how Ender grew as a leader during his time at Battle School, there simply was no attempt at ensuring his resilience. In fact, Graff seemed perfectly comfortable with the potential of Ender becoming mentally, physically, and emotionally incapable of functioning, as long as he defeated the Formics. Anderson pushed back, and at one point, Ender was afforded a visit back to Earth to visit Valentine, his sister.

Today’s military understands the role resilience plays in ensuring long-term health of its warfighters. Emerging military programs (some involving simulation-based training) are being tested with personnel, and counselors are being trained to ensure that those who go into harm’s way come home fully functional. New academic curriculum are even being launched to support such counseling – as an example, Liberty University offers a masters-level certificate in Human Services Counseling: Military Resilience (Liberty University, 2015).

While one can argue that Ender was selected based on his “win at any cost” ethic, and that selection saved the entire population of Earth, there is no debate that Battle School did an abysmal job of building resilience into its training. While Battle School’s training regimen and Ender’s natural leadership abilities provided two legs of the ready stool, the resilience leg was broken, which led to a broken Ender in the end.

Ethics

Today’s military places a heavy emphasis on ethical performance of its troops. Hardly an issue of *Army Times*, *Air Force Times*, *Navy Times*, or *Marine Corps Times* hits the newsstand without an article involving a service member being relieved for some violation of ethical conduct policies. Yet ethics was never mentioned in *Ender’s Game*. What ethical issues were apparent in the book? Did Graff and Anderson always behave ethically? Put yourself in the role of Graff’s commanding officer – where would you draw the line with his behavior, and how would you counsel him?

Mentoring

It takes time to grow subordinates, and the mentor/protégé relationship is crucial in developing the next generation of senior leaders. Ender had little mentoring, Petra being perhaps his only mentor; however, he mentored many Battle School students informally through his practice sessions. In addition, he developed a fairly close mentor/protégé relationship with Bean. As a subordinate, did Ender’s limited mentoring slow his progression in Battle School? As a leader, what worked well and what needed improvement in Ender’s mentoring of Bean?

SUMMARY

Ender’s Game, though a work of fiction, presents the power of simulation as a training tool. From his entry as a “launchie” at Battle School to his defeat of the Formics at Command School, Ender Wiggin utilizes the power of simulation to train himself, his peers, and his subordinates. All three domains of modeling and simulation are represented, and many traditional and emerging technologies appear throughout the book. Orson Scott Card’s book can also serve as a text for introductory modeling and simulation classes. Instructors can develop lesson plans based on the characters of Ender, Anderson, and Graff, as each utilizes simulation environments with the ultimate goal of making Ender a hero. As it is a novel, *Ender’s Game* is not intended to be a textbook, so readers should try to understand both proper and improper uses of simulation as a training tool.

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