

## FormulaT Racing: Combining Gaming Culture and Intuitive Sense of Mechanism for Video Game Design

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**Abstract:** While video games are typically labeled either commercial or educational, little has been done to amplify the educational value of popular commercial games. Using data from a pilot study of children playing commercial games we have developed a prototype video game called FormulaT Racing. This game is designed to fit into gaming culture while simultaneously providing an environment that draws on players' intuitive beliefs to move them to a qualitative understanding of basic kinematic principles.

### Introduction

Video games constitute an important part of the lives of youth in today's world. The PEW Internet and American Life Project claims that as many as 97% of American youth play video games and 50% play games daily for an hour or more (Lenhart et al., 2008). Although much has been written about the potential for video games to serve as powerful learning environments in science (Gee, 2003; Kafai, 1996), these games are typically dubbed "educational" or "serious" and are not embraced by the mainstream audience.

We believe that commercial video games are an untapped domain ripe with educational potential. In an effort to increase the educational value of commercial video games we have designed a prototype game we call FormulaT Racing. While others have attempted to build "games" to teach kids about kinematic principles, our game is different in that it was designed to foreground kinematic principles while still being consistent with current video game culture. Specific design components of FormulaT Racing are based on an analysis of a previous ethnographic study of children playing commercial racing video games. In this study we uncovered features of games that instantiated the player's intuitive schema of velocity, acceleration, and momentum. These design components were then altered and adapted in our design of FormulaT Racing.

### Theoretical Framework and Method

Our attempt to create a design framework for increasing the educational potential of popular commercial video games proceeds in three phases. The first phase of this work was a study involving ethnographic observations and semi-clinical interviews of participants playing *Burnout Paradise* on the Xbox 360, and *Mario Kart Wii* on the Nintendo Wii. These interactions were videotaped, transcribed, and coded inductively in an iterative process over multiple passes. To uncover the game designs that activate players' intuitive theories of motion we created an analytical framework that utilizes Roschelle's (1991) concept of registrations and diSessa's (1993) sense-of-mechanism. Roschelle (1991) describes registrations as, "the way students carve up their sensory experience, give labels to parts, and assign those labeled parts significance" (p. 9). In our study, a player may develop a registration of "turning" as a combination of a specific manipulation of the controller as it relates to on-screen action. To analyze how players label registrations, we borrow diSessa's (1993) notion of sense-of-mechanism. In diSessa's well-known framework, knowledge elements are composed of phenomenological primitives (p-prims). While playing racing games players commonly instantiated Ohm's p-prim (that more force yields greater result) by "mashing" the gas button even when their vehicle was at its top speed.

In the second phase of our overall research plan we are constructing a prototype racing game that incorporates a specific design framework developed from the analysis of the ethnographic study. In the study, players attended to three key design components: the spatial relationship between the player car and other vehicles or features on the screen as a representation of velocity, the tendency to assume acceleration was a static property of the player's vehicle, and the importance of the analog nature of the controller. FormulaT Racing is designed to look and feel like a typical commercial racing game while incorporating specific and subtle design tweaks meant to move these intuitive theories of kinematics to a more expert-like understanding.

### FormulaT Racing Design

FormulaT Racing was created in the agent-based software NetLogo (Wilensky, 1999). The ability to easily look "under the hood" and quickly manipulate code makes NetLogo an ideal programming environment for a video game prototype. FormulaT Racing is a microworld (Edwards, 1995) designed to cue the same registrations and p-prims found in popular commercial racing games. Specific design features of FormulaT Racing include the use of a motion-sensitive analog controller, external cues as a context for velocity and acceleration, the use of formal terminology, "just-in-time + 1" feedback, action-oriented representations for qualitative vector addition, and a scaffolding system consisting of multiple representations. These designs are intended to tweak the

previously identified registrations to more accurately represent velocity and acceleration and to subtly encourage the player to notice relationships between the two quantities.

FormulaT Racing puts the player in the shoes of a new driver as they train to join the FormulaT Racing Circuit. Early “levels” are structured as driving skill tests and take place on a straight continuous track. Examples of skill tests include driving at a constant velocity, driving at constant acceleration, and learning to manipulate a motion sensitive controller to achieve these desired states. In our observations we noticed that players typically “mashed” the buttons often leading them to miss the acceleration phase—for them the car was either going slow, or fast. In FormulaT Racing players utilize a Nintendo Wiimote controller that is motion sensitive to manipulate their car. Actions were carefully mapped to highlight the vector nature of quantities and to be body-syntonic and cognitively coherent. For example, acceleration is achieved by rolling the controller forward (positive) or backwards (negative). Many challenges force the players to dynamically adjust the roll applied causing them to reflect on acceleration as a changing quantity that directly impacts velocity.

Before racing, players are given their objective from a pit boss. While racing the pit boss occasionally gives tips and corrections using audio cues to help the player achieve level objectives. Key to the pit boss design is the use of formal physics terminology and “just-in-time +1” feedback. Because the informal nature of the typical language utilized in video game helps to draw the player into the game, it is important for our prototype to carefully consider the use of formal physics terminology. Our solution was to keep the “attitude” of the language, such as having the pit boss speak in a southern accent, but to use formal terminology, such as “velocity” rather than “speed.” When giving corrective advice we decided feedback would be more valuable if it were given just after it was needed. This “just-in-time + 1” feedback allows the player to reflect on the outcome of his errant technique so that he can better understand why a certain technique works in a given situation.

Data from ethnographic observations suggested players typically determined their own vehicles velocity and acceleration by looking at the spatial relationships between the player car and the competition cars. To utilize this registration, in each of the early levels the player sees his own car, a street complete with lane markers spaced a regular intervals, and a competition car. Because FormulaT Racing does not provide a speedometer, players must utilize the other car on the track to determine if they are succeeding in the task. For example, in the constant velocity challenge the player must catch up to another car on the track and match the other vehicle’s speed (the other car moves at a constant velocity). We have also incorporated a velocity vector addition feature in the disguise of a “reverse time” special ability. Once players obtain this ability they can press a button that moves their car back a few time steps and reveals an animated vector arrow showing their current velocity vector. Players can then dynamically draw a new vector that will be added behind the scenes. Through repeated use players can gain a qualitative sense of vector addition.

Taking a constructionist design approach (Papert & Harel, 1991) FormulaT Racing also incorporates a set of tools that encourage reflection by changing the nature of representation. In later levels, rather than drive the car using a gas and brake button, the player “paints” the racetrack different colors, each color corresponding to a different speed (acceleration can be painted as well). Another level forces the player to construct a velocity vs. position graph that the car then matches as it drives around the racetrack. In these levels the player must demonstrate a deep understanding of the relationship between velocity and acceleration to be successful.

## Conclusion

We’ve presented FormulaT Racing, a prototype video game designed from pilot data of kids playing racing video games. The intention of FormulaT Racing is to create a game that accomplishes the twin goals of being consistent with kids’ video game culture and making salient core kinematic concepts. FormulaT Racing will next be implemented in an after-school program. The new game designs will be evaluated by observational data and with an adapted post-test method. Data from this experiment will be presented with the poster.

## References

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