PROFESSOR: OK, let's see, some administrative stuff, first of all, Wednesday's our play test. So it's an internal play test. You're going to be playing with each other games which means chances are you are going to get barely enough time to play one person's game, and enough time for that group to play your game. So I'm just going to just, basically, pair up teams. Hopefully, I think we have four teams. So I think that works out just right.

One thing I will certainly recommend before going on to Wednesday's class is making sure that you had a chance to play test with, at least, someone who's not in your group. And the reason for this, what you want to be keeping an eye out for, are rules that you've already agreed on in your team, but might have to learn it to write down somewhere. I want the rules written down.

They don't necessarily need to look great. Typed is awesome because they're easy to read, and they're easy to revise later. It's not actually a requirement. But you've got to have them written down. You should be able to just put it in front of a person. I will suggest that you bring a copy to the office. If you want to come in early on Wednesday, or I could, maybe, grab the Xerox if you just bring a couple of copies so that the entire group of four people is going to be testing your game, which means, all users at the same time while you're explaining it to them.

If you're in a situation where you already have rules that you think could be understood without explaining, I would suggest not explaining at all. Just give them the rules and see what they make of it. It's going to be very informative that way. Not every single team may be in that situation. They may not have that much confidence in their ability right now.

If you think you've gotten all the rules written down but you just kind of feel not quite so confident that everything is in there, do it anyway. Just don't explain it. Give it to them. See what they're having problems with and then you can explain it. It will still be informative. You'll still be able to get that data point of what should we have written down as a clarification, as a complete omission, what needs to be reworded before the game ever starts.

But I do fully recognize that there may be certain teams that do not have a set of rules that comprehensive yet. In the end, you'll want to get the operating test and time. So it's going to take half and hour for somebody to understand your game just by reading your rules, then you do want to try and cut that down. Eventually, before you send me your game you'll want to be in a situation where someone can understand your entire game quickly, comprehending the rules. What's up?

AUDIENCE: When we're play testing and timing, we weren't sure or we didn't remember, or we didn't read carefully enough, what is the maximum time that the game has to take? And does that include set up from a complete novice, or does that include, are you allowed to explain the rules and have totally experienced players go at it, and once experienced players go at it they have to take a certain amount of time? How does your

PROFESSOR: It was supposed to be for novice players but I'm just going to check the actual syllabus.

AUDIENCE: Do we have to be able to explain the entire game, run through an entire play through and all that, in 10 minutes?

PROFESSOR: That one I wasn't sure. I think it's actually on your play through but give me a second. I'm going to look up.

AUDIENCE: I'm pretty sure it says 10 minutes. Yeah, 5 or 10 minutes including setup and play.

PROFESSOR: Including set up and play. But that does not necessarily

AUDIENCE: It shouldn't include reading the rules.

AUDIENCE: It should not?

AUDIENCE: It should not. 10 minutes is way too short a time to read and understand and then play a game.

PROFESSOR: Yeah, let me just verify that.

AUDIENCE: Walks and words. That's about it.

AUDIENCE: Our game takes two minutes to play at the moment.

AUDIENCE: What we'll be able to do is take a really long time for premium effect and have some more information written on these cards. It's just taking the time to write it so that way if somebody's busting a move

PROFESSOR: So it's true. It doesn't say 10 minutes that you need to be able to play and understand the game in 10 minutes. So I'm going to say, set up and play has to be 10 minutes. So it's like, every time you reset the game and you play to the end, that should be under 10 minutes. If it takes longer than that to understand the game, that's fine. But frankly, if it takes more than 10 minutes for someone to understand your game, you have a problem. And the problem isn't going to be one that's going to affect your grade, it's going to be one that you can use the processes in this class to reiterate on to improve your game to the point where it doesn't take that long to understand.

Reading the rules should not take longer than playing the game. There are games like that but try not to make those games and not when it's the first time. So I would say in for the explaining of the rules should take within 10 minutes. Right now, it might be OK if the actual explanation requires someone who's actually an expert in the game to explain it. By the end of this assignment you should be definitely getting to the point where you don't even need that. Just a new player with your rules should be able to understand and play your game in 10 minutes.

It could involve discussion of the entire group of your players. You've got four people in let's say it's a card game you have four people and they're all looking at the rules simultaneously, and your friend says, where does it say so and so? And somebody else who has never played your game before answers that. That's fine. And that's actually how a lot of people play games. Sometimes people play in quick thought rules. This is all you need to know to play your first round of cards, and that actually helps a lot of people to get started. And then you're picking up the

AUDIENCE: Lowers the activation energy.

PROFESSOR: Yeah. In the end, more people play your game. That's good. So that's on Wednesday. Everyone please come on time because every minute of this time wins some recognition or pizza [UNINTELLIGIBLE] and if whole teams don't show up Who's aligning a game that has to be played by both players. So there's some teams. Two? Three?

AUDIENCE: Two or four.

PROFESSOR: Two or four. OK. All right. No, that's cool.

AUDIENCE: So even if a guy didn't show up on time that's OK.

PROFESSOR: OK, so that's the preparation for Wednesday now. I do want to apologize for Friday's lecture. I was on a lot of meds. You may or may not have noticed that I was having a splitting headache and was not the best lecture that I have given in my entire teaching career. In fact, it's probably the worst lecture I've given.

AUDIENCE: No. I didn't notice.

PROFESSOR: It occurred to me that there might just be a better way to get some of those concepts across other than me yammering for three hours. And what I'd like to do is revisit some of them but actually do a bit of an activity. I have never done this before so this is not tested. You guys are the first iteration.

AUDIENCE: Oh. I feel honored.

PROFESSOR: But basically, what I'm going to do is I'm going to go through these terms again, explain them one more time. You guys have accurate clarifications or anything. And then each in a group of about, I think two people, we're going to pick the game that pretty much every one in the class should sort of know. Maybe they don't know the exact rules but you know of the game, and analyze that game across these different axes. And the idea of that is that, if you get used to this then you can do that same thing to your own game. And that may shed light on how your game is balanced, how your game is balanced especially between chance and skills because we get a topic of this class.

But also question, is our game doing what we want our game to be doing? So that's the general outline. So there's one more thing I want to mention before I go into that. And Jason actually brought up a point at the end of last Friday was that he noticed that our two end robots, Mr. Roboto and Badass Mofo 600.

AUDIENCE: 610.

AUDIENCE: Yeah, 610.

PROFESSOR: It's the upgraded version.

AUDIENCE: It started at 608 and then there were a couple of iterations at least on Saturday.

PROFESSOR: One of them was purely deterministic but horrendously complex in the sense that

AUDIENCE: It wasn't that complex.

PROFESSOR: Not in the sense that it was difficult to explain what it was doing but difficult to predict what it was going to do. This was the one that will start it's turn order based on the number of hit points that it had.

AUDIENCE: And take the number of moves based also on the number of hit points it had.

PROFESSOR: So it's entirely algorithmic. It's just following it's root every single time. The other one was pretty much random, right? Who of Mr. Roboto which should have in a die roll every round. And it just hit something. And we ended up with the closest fight of that day, I think. And that does drive home the point that at some point and time you can get complexity through showing deterministic rules. That frankly, it's as hard to predict as pure randomness.

AUDIENCE: My card game is like that.

PROFESSOR: Your card game is like that? The nice thing about that is that if you have deterministic rules, you can see why it happened. You can see why, wow I didn't expect that to happen but I can see why it happened.

AUDIENCE: He was so sure he was going to win. He was so sure he was going to win but then we

AUDIENCE: It did not turn out as such.

PROFESSOR: That's a desirable trait. It's a lot better than just saying, well it's a die roll. The nice thing about die rolls is that it does take it out of your control. It's kind of designed to make it not skill based and as a result of that, you get people who are lagging, who are having a harder time playing and finding the unskilled base way of catching up. Which is awesome if that's what you're going for.

And then the other one is if you just make it deterministic but complex enough so the behavior is just hard to predict, but logical ones that are actually happens then you kind of get the same result. It all balances out. Die rolls are really easy to enter. It's difficult to actually come up with rules that deterministically give you the kind of complex that you're really looking for. But it's a nice thing to go for.

Of course, to get the complexity sometimes you need so many rules that people just can get bored. It's like, wow, this is really complicated. I'm not sure whether I can figure out what the next step is going to be and then they just give up. That's the down side of really complex deterministic behavior. It's neat that you saw both of those playing off of each other and them behaving in pretty much unpredictable ways. And yet, getting nicely balanced results. So the book we leave [UNINTELLIGIBLE].

So now, I'm going to be actually deeply, deeply plagiarizing from Salen and Crumb. Katie Salen in Eric Zimmerman from *Rules of Play* which is one of those big thick books I brought in on the first day. I'm not making you read it because I find that book takes three pages to explain what could have been explained in one, which is why I have a whole bunch of summaries in here. But what that book does do is give you very, very concrete terms that are pretty well accepted. They're not necessarily among game designers, among big people [UNINTELLIGIBLE] experiments. And I've got some of those for you to refer to.

I'll touched a little bit on information theory on Monday. That model of how a signal goes from someone who wants to send it through a transmitter and goes through some sort of channel, is received through some sort of receiver to a person. If the person who wants to send a signal is actually the game, the game state, and is transferring information to a player, who need to get information about what's going on in the game in order to make a decision then, you can see how this applies to game design. And in between you have [? moints ?]. You have the thing that prevents you from knowing exactly what the game state is. And there are certain words that are associated with that level of uncertainty. Uncertainty and certainty are two word study searches to begin with.

So the uncertainty includes both your inability to know what's going to happen next due to chance or due to really complex behavior, as you saw in both of the robots. It's just the degree to which how much the game all the different states the game could take, either they need the next turn or throughout the entire play of the game. And in information theory, they actually also use the word information almost interchangeably. Unfortunately this gets kind of confusing because people don't actually use the word information in that sense in day to day.

In fact, I'm going to propose a different way of looking at it that also uses the word information in a completely different way. So I'm actually going to stop using the word information for now. I'm just going to call it uncertainty which is pretty much all the different things that could happen in the game, either in their next turn or throughout the entirety of the game.

Certainty is the degree to which you have knowledge about what could happen.

Chess board pieces could be configured in any position but one move after the opening, there's only a small set that could possibly happen. It's probably on the order of where only one side is moving for the first time. Any one of the pawns could move 20. 20? Yeah, the knights could move, yeah. So there will be 20 different possible things. So that's kind of the degree of certainty that you have among all the different states, all the uncertainty of this chess board. You are certain that it's going to be limited to this chunk.

And your knowledge of what that ratio is, of how much you know could be happening, based on what you know of the game rules, based on your experience of the game, based on your skill in the game, to the stakes that the game could possibly take is called risk. So you can flip it the other way around and say that if the uncertainty of the first turn is 20 different moves but you are certain that the guy let's say I'm the opening player, I played white and I really only know how to make three of those openings effective, and the person I'm playing against knows that really, I only know three openings, even if I only know two, then that person's degree of risk is limited to the range of possibilities that branch out all of that 2 out of 20.

So that's one way that you can sort of describe risk. Let me see whether there's a more technical term that I can describe that with. I skipped a page, didn't I? So one thing that I want you to think about later, actually for the analogy step we're going to do. I want groups of two. 2, 4, 6, 8, 10, 12, 14, 15. Mostly groups of two and one group of three, actually, let's just do it in groups of three. It will be easier that way.

And just think about and pick a game first that you think that you can probably mention in this class without having to explain to everybody else exactly how this game is played. It could be a computer game. It could be a board game. It could be a card game, something fairly [? modern. ?] And I want you to think about what are the things that, what are all the variables that you need to know in this game. Doing the [? variable terms ?]. If you're doing something like a game of Caustic Encounter or something. Then you can say that every single race as a unique power without explaining to me every single power. I think there are 100 races in that game.

AUDIENCE: Which game?

PROFESSOR: Caustic Encounter. Oh it's fun. You will get a chance to play it later this semester. Let's see, so think about what are the variables that you got to keep track of. That's kind of the degree of uncertainty. That's the amount of information that could be in the system with that [UNINTELLIGIBLE] User does all the different range of possibilities, all the different things they got to keep track. What do you know for sure a single playing in this game? What do you know in your first turn and what information do you tend to pick up along the way?

Let's see, so let's start with that. You've got just five minutes. It doesn't have to be an exhaustive list. So let's just split into groups of three. The first activity we're going to [UNINTELLIGIBLE] every single one of these games through all of these different answers. So I'm just going to start, actually now, and if we run out of time to do this, we can always do it after class and we can talk about it. But we're going to go through all of them. So I'm going to breeze through this. So starting with this team then, moving all the way over and do you want to just talk about

AUDIENCE: So we decided to go for *Scrabble*. And so, in terms of variables, you have to invent it by individual tiles. Their tiles are uncertain and yours are fairly certain. The one's on the board were certain because they're faced.

PROFESSOR: It was [UNINTELLIGIBLE]

AUDIENCE: Yes. Another variable, well I used a variable, it's the bonus squares on the board. Even though there's stakes on the board, they're variable in terms of, as more tiles get played, some of them become open and some of them become closed and you don't know which one's are going to be working closed.

PROFESSOR: True. True. Yes. So that's something as you don't know how that's going to turn out during the middle of play. So one thing that's interesting about word games, especially in *Scrabble* and crossword puzzles, in general, is that a lot of them rely on the fact that the English language, in particular, is actually pretty redundant. We can take about 50% of the letters out from a word, this very long word, and can still figure out what it means. That works really well in crossword puzzles because if you get something like 25% of the word, you can actually still figure why the associated that clue. But *Scrabble* rules are made easier so that it is now possible for you to make connections between disparate characters and find a word that's going to fit that. Of course, part of the problem actually has anyone played *Words with Friends?*

AUDIENCE: Yeah, against my brother.

PROFESSOR: This one like *Scrabble,* basically, right? The same folks who made *Words with Friends* made a game called *Words with Pirates*. And I have a screen shot here of the game I was playing yesterday. And basically, you have way fewer letters. You have h, a, r, a lot of r's, I and an exclamation mark. So the number of letters that you can get, the quantity of the letters that you get are the same as in *Scrabble*, but the range of the different letter you can is way lower. With means there's a lot less uncertainty. Because this language, this parrot language has so much I want to be very careful to use the right word here so if I'm using the right word here, this is actually a very non redundant language because a, r, r, r is a word. A, r, r, r, r is a different word which are balanced. So there's actually very little redundancy. I see a, r and I think, that could be any number of words. And as a result you notice that this game of *Word*s *with Pirates* it results in an incredibly dense word. Of course, I can show [UNINTELLIGIBLE]

But you can't do that with *Scrabble*. *Scrabble* spaces go empty and get locked out because, unless you have an incredible knowledge of the Scrabble dictionary, for the most part, you don't know those exploits that I'm going to then slide in an extra character. But most people's knowledge of English doesn't happen in that board game. So anyway I thought that was specifically useful for an illustration. OK, so *Scrabble*. All right, cool. Next game.

AUDIENCE: We did *Go Fish* so some of the variables depending on the equation we had were like every players hands and the pile of cards in the middle that you can pick from. We thought about some of the uncertainty being what cards the other player has.

And the challenge that comes out of it is them asking what cards they want and you asking them for cards. And there's noise because just because they're asking for a certain card can imply what they have in their hand, but it doesn't necessarily tell you what they have.

PROFESSOR: Right. It only tells you what they don't have in their hands. Sometimes it tells you what they don't have in their hands. Sometimes they give you a card and I forget the rules. If you have multiple threes and someone says, got any threes? You give them all three?

AUDIENCE: Yeah.

PROFESSOR: Yeah, OK. So

AUDIENCE: Why do you have three 3's? You put a pair down. That would just be dumb.

AUDIENCE: That means you're a bad player.

PROFESSOR: For the most part in that game that's your one channel of finding out what the state of the game is. The game states what everybody has and hasn't had. Cool? Cool? Cool?

AUDIENCE: We did Mario Kart.

AUDIENCE: There's a lot of uncertainty and a lot of other things to keep track of. So the things you can't possibly keep track of but that are really important in the game are what's going to come up when you hit an item block and what items people around you have. So you might think it's safe to bump another player but if they have three green shells they can activate that then and blast you out of the map.

AUDIENCE: Another one is what position you're in because if you're in first place and a blue shell hits you that's also what position you're in, which is what other people are in, and stuff like that.

PROFESSOR: Right. So the probability of being hit by the blue shell is way higher when you're number one.

AUDIENCE: So you gather information through your people range which is also a function of, basically, where you are on the map. And so the information you're giving about other players depends on where you are, interestingly. If they're immediately in front of you, you have a lot more information than if they're behind you, you have a lot more information than if they're way far away from you.

PROFESSOR: Right. Because if they're behind you or they're way far away from you, you don't know what weapons they've got ahead for you, for instance. You generally know what position others people are in but that's all you got. So [UNINTELLIGIBLE].

AUDIENCE: And then there's different paths and levels so you might get someone in the same position as you but they're not at the same point because they're at a different branch. And then, good also the very given motives of different cars. So in Mario Kart 64 if you take Bowser and you're playing as toad, you can ram into toad until you go flat.

AUDIENCE: Yeah. I've run into Bowser before.

AUDIENCE: So one of the little risks that you get in Mario Kart is that the kinds of weapons that you get are pretty much weighted based on where you are in the game. If you are at the back, you get all the awesome weapons. Because the game

AUDIENCE: You get the star. The eraser on Hero station was way more weighted than

PROFESSOR: Sure. There are more obvious versions of this. I think Super Monkeyball axis, too, actually. When you're right in front, I think, all you get is bananas, is that the only

AUDIENCE: In Mario Karts? Bananas and one green shell. That's pretty much it.

PROFESSOR: You get a pile of junk later.

AUDIENCE: And also, the fake mystery box.

PROFESSOR: And half way through and half way games, the waiting is, I'm going to guess roughly linear. So the basic idea is one of the things about risk is that every time you take up a new weapon you are, basically, taking a gamble about what you're going to get. If you're already holding a weapon sometimes you can choose to discard that to pick up something new. And I believe leader iteration you can [UNINTELLIGIBLE] think of that.

So now, that's one element of risk, right? What do I know? I know what I got. What else do I know? I know what position I'm in and I know that if I run into this box right now and I got rid of what I had, I could pick up a cooler weapon. There's a probability associated with that and that's, yet, another [UNINTELLIGIBLE]. One way to think of it is that there's such an outcome, which I said a probability associated with it, you are going to get a weapon.

AUDIENCE: It might be cracked. You only really gain a sense of the hard way from experience of playing with it.

PROFESSOR: Yeah, it's one of those things where your certainty of this game goes up as the number of play. Cool.

AUDIENCE: We did *Monopoly?*

PROFESSOR: Sure.

AUDIENCE: So *Monopoly* basically, what's certain is who owns what property, essentially. And it's technically certain how much money everyone has though keeping track of all that information on a turn to turn basis can be difficult. So there's a little bit of relative uncertainty just due to the quantity of information there. Yes, so you gain uncertainties.

It's actually that *Monopoly* has very different opening and end games, essentially. Towards the start of the game there's a lot of uncertainty about how other players are going to value property that you give up. Owen was telling me. I wasn't even aware of this. In *Monopoly* when you decide not to purchase a property it actually goes up to auction. It's like I have never played with that rule.

AUDIENCE: And it's an open auction and so you don't know what other people's valuation are so each time you'd be taking a risk if you didn't actually want it at that price.

AUDIENCE: That actually makes the game more interesting.

AUDIENCE: It turns out the game is not that much more interesting. Even when you have the auction system [UNINTELLIGIBLE] it's still pretty boring.

PROFESSOR: Can you see the like degenerate strategies. We will get to them.

AUDIENCE: Towards the end of the game, basically, it's also a lot of uncertainty about what players are going to be well, these aren't part of the rules but whether they're going to be willing to trade with you, whether you can do things like manage to get into jail so you can stop landing of people's properties. Chance is, of course, another level of uncertainty there.

PROFESSOR: Yeah, it's weird about the risk associated with an auction because you kind of know the seller. Especially in the early game, you have a vague idea of how much people could possibly bid on this. Not more than the amount of money that you have, although [UNINTELLIGIBLE] a mortgage something that he had, just to get the cash flow at auction. But it's one of those things that you know is fairly built with certainty, and so it's true risk. Ok?

AUDIENCE: So we chose chess. Chess has no uncertainty in the game. If I would say an answer to you would be, you don't know what you're opponent is going to do. So you have to make a move assuming he's going to do something completely different. And as well as risk in the game, the only risk is also not knowing what your opponent's going to do. So he could do a series of moves which causes you to be in a situation where you have to lose a piece. That's pretty much it.

PROFESSOR: That's cool. I would argue that not knowing what your player is capable of is deep in uncertainty. And in fact, it's a usual amount of uncertainty in the game. It's true that the way and how the pieces move and where the pieces are placed, everyone knows that. And we're going to get a mixed one. It's a game of perfect information. The game stake is no dice. You know exactly what's going in the game unless you're playing with a five year old who didn't put the piece right down in the square.

AUDIENCE: So I guess something where it would be a lot more noise for the game would be if you're playing something like speed chess because then it's like oh, you just have to think fast and it's a lot harder to realize what's going on.

PROFESSOR: Yeah, that is true because now you're limited by your own cognitive bandwidth. So that's true. It doesn't change the amount of uncertainty. The uncertainty of the game really is your opponent and what's in that person's head. The knowledge of openings and knowledge of different moves, whether that player has seen something that you haven't seen or knows of a counter that you [UNINTELLIGIBLE].

AUDIENCE: Or there's another way to give the impression that they know exactly how to counter if you're doing any kind of loading like.

PROFESSOR: Sometimes other counting on them to do something, and then they don't it's like, why didn't you do that? I would have done that.

AUDIENCE: It's like golf where you have to pretend like you really look like you know what you're doing.

PROFESSOR: Or poker. OK, so that's one way to look at your game. What you know, what you don't know. What's the probability of the certainty and you know the answer. And, of course, not as you. As a game designer you're thinking, what do your players know? What do the players not know? What can your players do? And a reasonable guess of what likelihood something is going to happen. Also, the things going to be true. It's like, OK, I don't know what card that person has but there's an 80% probability that that person has jacks of higher of the trump because that person bid on the trump. That's a fairly good guess. A low risk guess.

OK now, we'll go to the other schema which is the information systems. Now, we're talking a little bit about perfect and imperfect information. Perfect information games, you know game state. Everyone knows games state. No player does not know a game state. Imperfect is, the information, OK, there's something you don't know. Maybe it's card games in particular because cards have two sides. Cards are typically used to hold back imperfect information. Anyone play *Stratego*?

AUDIENCE: Yeah.

PROFESSOR: Now that's incapable of complete, imperfect information [UNINTELLIGIBLE] the game. You know every single piece. There's nothing random in an entire game. There are no die rolls. There are no random shuffles.

AUDIENCE: So when the other guy chooses to play where he just places pieces, it can be perceived as random to you.

PROFESSOR: Can be perceived as random, it is true. But let's get really specific about turn around. What it is, is that it's actually uncertain. It's not actually random, it's a decision made by that player who's got the right moves. So, actually one, objectively, it is not random. It is perceived as random. It's perceived as, effectively random because really the person couldn't put his pieces anywhere within the first three rules, or something.

So however, that's kind of a blunt tool. Is this game a game of perfect information or imperfect information. That's a yes /no question. Does it really tell you that much about your game. Asking, OK, what is actually random and what is not actually random but may be perceived as that, is a slightly better question. Because you can think, OK, if I isn't clear I know that's not random but it could be anything because of what the other player has done. I will treat it as random. I might as well do all. And when you're designing for that player and you are doing all your calculations, just taking it as random.

There is a game theorist not game theorist the game studies scholar of games, Ceila Pierce, who works over at Georgia Tech. And her proposal is that a more useful range of questions to ask would be what's known to all the players? And in a game of perfect information everything is known to all players. What's only known to one player? What's known to the game? Especially for a computer game, the computer knows a lot more about game state. Sometimes that even comes down to rules.

So if you've ever done Force Battles in something like Metriod or Castlevania, for instance. There are rules that every single process is going to react to anything that you do. Maybe it's based on time. Maybe it's just the sequence of action that are already done. Like the EIHI robot that you guys programmed in class [UNINTELLIGIBLE] You don't know those rules going into the game. Those don't prevent you from playing the game. In fact, part of the fun is figuring out the rules and figuring what the pattern is and explaining it. So that's an example of a thing that's known to the game.

Other things that are known to the game are actually now, maybe that's not a good one. I'm going to stick with my topic because randomly generated stuff, like there is a shuffled deck. Shuffled decks are one of those things where it's a little bit unclear about whether the game knows what's in that stack. It's true that you shuffled it, so it's randomly generated, but once it shuffled it, it is now in a fixed order. So the game knows what order that's in even though essentially randomly generated, it's not randomly generated every single turn. But it's a good question to ask.

Even if it's not an easy question to answer, it's a good question to ask what's known to the game but not known to the rest of the players? And what's this randomly generated? Even if the game had a brain we would have no idea what these things turn [UNINTELLIGIBLE] because it's pretty terrible. So use those games again. Every single one of those games they are talking about, what's known to all players? What's known to one player? What's known to the game and what's just randomly generated? Go. Shall we just do the [UNINTELLIGIBLE]

AUDIENCE: So we changed our game to poker. Texas Hold 'em now. So know on your test. So it's imperfect information because you know what's in your hand, you know what's on the board, but you have no idea what anyone else has. They can try and trick you so it's maybe perceived. It's perceived knowledge. So let's say they play a large bet. It's perceived that they must a good hand but it's not necessarily accurate. So it's not really an objective base however, it is subjective whenever you can finally show your hand. Then either you've won or you've lost. It's not really up for debate.

AUDIENCE: So I guess it could also be whether you know, like again with chess, what the other player knows, whether the other players know conventional poker conventions for folding or not.

PROFESSOR: OK, let's see. Other things that are a lot of [UNINTELLIGIBLE] especially poker, that is known to all players will be things like, what are the number of kings in the deck? What are deposits and what are all the different hands that you could make, and what are the point values? So that's just one example of things that need to be known by all players. The assumption is that all players know that. Sometimes all players don't know all these.

AUDIENCE: Yeah, memorizing the probability is a huge endeavor.

AUDIENCE: Really big player know the objective probabilities in any given hand.

AUDIENCE: Actually, a lot of casinos will let you bring in a card with probabilities.

PROFESSOR: Really? I'm surprised that they'd let you do that. OK. All right. I guess they couldn't

AUDIENCE: Even blackjack. I'm pretty sure with blackjack, too, you can bring in a card with probability.

PROFESSOR: So the things that are known to the game would be, of course, shuffle order. I guess this happens more in blackjack where you've got five decks all shuffled together and you know there's a number of kings and they're in there somewhere. So if all the kings get played out you know there's no more kings left in there and then you can do computations from there.

And one thing I want to clarify on objective and proceed. Objective doesn't necessarily mean that any one player knows whether this is good or bad. The idea is that if there was a third party observer who was not playing the game and knew all the game stake, looking to that, looking to the hands, knows what's coming up, or a computer running the game, that person, that computer will know the extent to which something is good or bad.

So if you've got a hand probabilistically you can tell well, this is a pretty darn good hand, or this is all ready probabilistically a crappy hand. It might be good for that game, right? It might be just like I have one pair, but it might be good if nobody has anything.

AUDIENCE: But probability you're not gonna have a good game.

PROFESSOR: But probabilistically you want to win. That's why you have poker player's saying things like, right up until this point I was winning and then I maybe lost in a tie game. But it's like, probabilistically they were doing everything right. And actually, a lot of professional players have disparages to say well, they were doing everything right, sure they lost a hand, but to them they were winning every one up until the point when he had to fold. OK, next game.

AUDIENCE: The *Monopoly* game was run through the all players, one player game, etc. All players know the board stakes so the people that are owners of any of the properties and [? what's owned ?] by the bank. Every given player knows the amount of money that they have, and also what valuation they placed on all of their properties, which is not known to other people except incidentally through their actions. The game knows the state of Community chance and, I'm sorry, Community Chest and Chance decks, and then there's randomly generated die rolls.

PROFESSOR: Die rolls, yeah. I'm forgetting whether *Monopoly* requires you to show your bankroll clearly.

AUDIENCE: I think so. I'm pretty sure.

AUDIENCE: If you want to know how much money somebody else has they have to tell you.

PROFESSOR: It would be an interesting thing to look up and see what the actual rule on that is.

AUDIENCE: Why is the game so popular?

PROFESSOR: Good marketing.

AUDIENCE: But then again it's very shallow and

AUDIENCE: It's really familiar. I asked friends of mine who happily play *Monopoly* but don't like to play, for instance, Settlers, and a lot of it is really, you don't have to think too much about it. It's just an excuse to sit around and talk with people. There's not that much that apparently distinguishes somebody who's like a incredibly good player or an incredibly bad player. It's got a bit of that any given Sunday feel to it so that you always have an opportunity to win. There can be dramatic swings of fate, and all that kind of thing.

PROFESSOR: So it's kind of like adult *Candyland.* You just go through the motions.

AUDIENCE: But I also have friends who are like avid *Monopoly* players who really believe that there's a deep skill to playing *Monopoly*. But I'm yet to be convinced.

PROFESSOR: There is a strategy. I'm not sure if it's a skill. OK, all right, cool. Thanks.

AUDIENCE: We did Mario Kart, again. Except for a couple of special stages, in general, players are aware of their welcome position to other players during the race.

AUDIENCE: Everyone knows the maps. [UNINTELLIGIBLE]

AUDIENCE: You're not sure if you know what other people, like what their special power ups are, because you can look at the screen and see what they have.

AUDIENCE: Yeah. Since you're playing to other humans there are situations where you definitely know what they had. I don't think

AUDIENCE: That's cheating.

AUDIENCE: It's a strategy.

AUDIENCE: In Mario Kart DS you know all your opponents items.

AUDIENCE: That's true. That's lame.

PROFESSOR: Suddenly, on a simultaneously multi player game where you're screen's divided into four or two, yeah, you know what your opponent has and decide if you're going to get into a Kart. Same thing for Halo.

AUDIENCE: Yeah.

AUDIENCE: It actually [UNINTELLIGIBLE]

AUDIENCE: Yeah. And let's see what else. So there's you perceive it as completely random especially if you don't pay much attention to it but it's more like weighted random in what items you get. So that's something you'll have to figure out as you go along, that actually, as you're further up, you get worse items. I actually think it's a good strategy in that game to remain in second place for most of the race and then go to first.

PROFESSOR: Now, the game knows those probabilities anyway.

AUDIENCE: The game definitely knows that. The game also knows who's going to get hit by a red shell, for example, when you launch it. It's not entirely clear to me as a player, when there's multiple people in front of me, who it's going to pick. When I shoot a green shell back behind me, the game knows what's going on. I don't. Is that my field of view? I hear it. Am I getting a result? Am I not?

PROFESSOR: The game definitely understands the physics way better than any human player can possibly understand.

AUDIENCE: Yeah. For sure. For sure.

AUDIENCE: The game knows all the player's positions and dull leads but it doesn't know what they're going to do or how their going to interact with each other. It also doesn't presumably, actually know what items are coming out.

AUDIENCE: Oh, and then another thing as players, you can learn the patterns of some of the hazards and be able to predict which way to go depending on how you know a certain

PROFESSOR: Just like knowing the map. Just like knowing the map.

AUDIENCE: Yeah. One of them are random, actually.

AUDIENCE: Some of them are random.

PROFESSOR: But one thing to keep in mind about randomly generated computers obviously, well, maybe it's not obvious but computers actually have a real tough time generating really random numbers.

AUDIENCE: It's starts to assume.

PROFESSOR: That why they're called pseudo random. So to some extent the computer knows but it's trying really, really hard not to know. What's really, really useful if you ever go into game design for digital games, to use that to your advantage. Because you can use that to reproduce problematic situations. It's like, yeah, write another generator that we have absolute control over and then use that to your advantage when you're trying to find bugs. Cool.

AUDIENCE: So just to remind you, we did *Go Fish*. So clearly every player knows what's in his hand, knows what pairs have been played thus far, knows how many cards people have, and stuff like that.

AUDIENCE: Generally, people should know what cards have been given from one player to another player. Although, they may have forgotten that. Sometimes there's a situation where most of the players don't know which pairs could be possibly made at a given point. Sometimes one player may know that because he might have one card and then somebody else gave their card to somebody else. Something like this. But the game definitely knows this. Also, the order of the deck is randomly generated.

PROFESSOR: Yup. And he's right at the beginning, first turn.

AUDIENCE: So For *Scrabble* all the players know the pieces on the board. They all know the letter frequencies.

AUDIENCE: They don't know what tiles they're going to get next. [UNINTELLIGIBLE]

PROFESSOR: That's randomly generated.

AUDIENCE: What if someone knows the dictionary, though? Like your opponent could have a dictionary, but not everyone knows it.

PROFESSOR: That's the knowledge that is both available to one player and to the game. Technically the game has an official *Scrabble* dictionary. If you're playing a digital version, they're probably using it. Your family, they probably don't accept certain two letter words.

AUDIENCE: Until *Pictionary*.

AUDIENCE: They also don't know what the other players have. So one person only knows what they have. But then the other three aren't really But then again, we discussed how if you're playing with two people you can probabilistically figure out what they've got. Or, figure out what you're going to get next when you draw.

PROFESSOR: It's also more likely for you to figure out as the game goes on and tiles get played what letters will never come up again.

AUDIENCE: At pro levels of *Scrabble* they do know exactly what's the final set. There's just a certain point that you get to at which point *Scrabble* players just know what play and work out and all the possible

AUDIENCE: At that point do you just keep letters that are more likely to work with what's in the bag. How do you use that to your advantage?

AUDIENCE: Well after all the tiles are drawn you know what your opponents have.

PROFESSOR: Yeah, you are trying to prevent them from using the letters that they've got. But most *Scrabble* boards, although I don't know if all *Scrabble* boards have this, they actually show the frequency in which the number of tiles where I'd be given that are in there. So it's actually expected that you're going to take this into account. It's like oh, there are only 4 h's or something like that, and they're all out. All right. There's none coming out of here.

AUDIENCE: Random other *Scrabble* facts. I found another one about *Scrabble* when I was reading about computational *Scrabble* playing. Apparently, in *Scrabble* tournaments, they have a chess court system, right, to making sure it doesn't go over time. And apparently, people set aside half their time to playing the end game in *Scrabble*. Which is the point at which there's basically full information. And then, you're just sitting there nodding out. Like, what the best sequence of play is to beat your opponent so then, it becomes like chess.

AUDIENCE: How much time do you get?

AUDIENCE: I don't even remember. So, high level *Scrabble* is completely different from the *Scrabble* that you play. It's crazy.

PROFESSOR: OK, all right. We've still got some time. Great. Let's talk about cybernetics. Cybernetics are, given that it was kind of invented at MIT, it's something that you probably encountered there. And we've mentioned this a few times, the whole idea of feedback. I want to break this down a little bit, though, because feedback works.

The official sense of feedback, and this theory of cybernetic systems as written by Norbert Wiener back in the 40's, I think, is that there is a sensor, something which measures what the system is doing. There is a comparative, which was, in his era, was that machine, and in our era is probably a rule, a logic, a statement, that compares this against some sort of set value or some sort of rule and decides to take action an activator.

And you can think of this this way, all as your sensor is the variable that you're looking at. Or, a set of collection of variables that you're looking at. So what are you looking at? Your comparable is a rule that you're comparing against.

I'm trying to pick a game that no one has mentioned here, so far, that has a good few facts system. Let's say I played a version of *Cops and Robbers* as a kid where every time the cop caught a robber, the robber would have to go into a jail area and put him down until someone tagged him. Someone from the robber team tagged him. And the basic idea is that the fewer people there are, and a few of us humanly are playing in a big space, the more robbers there are in jail, the easier it is for a robber to run. Actually, because they have more freedom. Sure, there are more cops to any given robbers so that you can do flagging [UNINTELLIGIBLE]

But one of the variables that we're looking at are how many people are trying to be in the jail. And an activator is basically what's the rule or what's the game dynamic that comes with the play. So that's a kind of interesting things about the *Cops and Robbers* situation. One had more space to run when all my buddies are in jail but there are a lot more cops going after me, and that actually means that it's easier for him to flag me even though I had more space to run.

So it goes up. Both are negative and a positive feedback system. More space to run is actually a negative feedback system. And how you tell the difference is is it stabilizing to my state or is it cumulative to my state. And it's stabilizing, which means I'm doing badly, my team's doing badly but this is now giving me an edge. Or, I'm doing really well and this is really crappy. Mario Kart is a type of these. Those are negative feedback. Those are things that basically reduce the gap between the best and the people who are doing well and the people who aren't doing well.

Positive feedback is cumulative. They're doing well, they're going to do a bit better. So the cops have got everybody but one and now it's a 5 to 1 game. That's a positive feedback system because now they can do tactics as opposed to everyone going after someone separate. And you have these two feedback views working together. There are tons of these in games. Games aren't really the kind of closed systems that cybernetics were actually originally designed to handle. In fact, only a few systems are digital systems in that way and games are actually better than most.

But let's talk about what's in all the games we're talking about. What are some of the negative feedback you experience, and some of the positive feedback you experienced. Mario Kart team, you got way too easy [UNINTELLIGIBLE] Think of some other game. Think of some other game.

AUDIENCE: Wait, that's what I didn't know. The AI automatically goes faster. There's a huge gap.

PROFESSOR: That's more than just a Mario Kart, actually. That's a lot of racing games.

AUDIENCE: Also, when if you're playing like the Grand Prix there's always three computers that are always better than everyone else, then all the rest of them. So they will always be the ones that are in the top four. Like they're in the top, always.

PROFESSOR: Mario Kart team, pick a different game. Go through all of the games. Think about chess. Actually, chess might actually be an interesting one for you.

AUDIENCE: No, but shot chess, where you retake the shot after

PROFESSOR: Shot chess?

AUDIENCE: Yeah, shot chess.

PROFESSOR: That gets too easy.

AUDIENCE: Well, it tends to be negative. It can be negative feedback but there's also the method of doing it where there's positive feedback. It depends on how you play.

AUDIENCE: Yeah. Winner takes any drinking game, pretty much.

PROFESSOR: It depends on what your goals are, right?

AUDIENCE: Such that you'd have it that whenever you take a piece you have to drink that piece. But then there's also whenever you take a piece you opponent has to drink a piece. So it can either be negative or positive feedback depending on how you play.

PROFESSOR: Yeah, but let's pick a version of the game. Ideally, pick the same game but if it's too boring pick something else. OK, so let's start from somewhere in the middle which and I think is this group right here.

AUDIENCE: So we took a pretty easy one but it's pretty like mathematical feedback. We did War. OK, statistically if you're winning, every time you win you're lowering the value of your cards.

AUDIENCE: You had to average the value to your deck.

AUDIENCE: Yeah. So mathematically it's negative feedback.

PROFESSOR: So, it's positive feedback, right?

AUDIENCE: Negative. [UNINTELLIGIBLE] the negative impact is you're lowering the average value of what's in your deck.

PROFESSOR: So which makes it harder for you to keep do winning.

AUDIENCE: Exactly.

PROFESSOR: So that's just negative feedback. Any positive feedback?

AUDIENCE: The small positive feedback would be insofar as you can't win unless you get all the cards. So that's winning hands gets you more cards, gets you closer to winning.

AUDIENCE: The more cards you have the closer you are to winning.

AUDIENCE: That's like saying, and you get with points, the more points you get, you're closer to winning. Therefore, positive feedback.

PROFESSOR: Yeah, I guess it does count.

AUDIENCE: Logically it works, but it's kind of a guess.

AUDIENCE: Well the only other one is if you have a war then you win those three extra cards and depending on what they are it could be positive or negative.

PROFESSOR: OK. All right. Which way should we go? This way.

AUDIENCE: We switched to Settlers. We got a bunch of feedback loops. Obviously, the more points you get, as soon as the points are cities and settlements, then the more resources you're going to get in the future and the more points you can build. So potentially one player just has so much stuff that he can just do whatever he wants to.

PROFESSOR: And that's positive?

AUDIENCE: Yeah. There's also negative feedback [UNINTELLIGIBLE] like it censors the relative prices of resources. The more one resource is worth at the time, each person, the other one's the more people try to build on that resource brick, then the less that resource will be worth in the future. So, over the long term they tend to balance out instead of having one go rapidly out of control.

PROFESSOR: Think about that one. That's interesting.

AUDIENCE: Also, the more, this isn't exactly feedback, but the more, the better you're doing, the less likely people are going to try to trick you somewhere.

PROFESSOR: Yeah. That, in my opinion, is the biggest negative feedback in the entire game. If you're in the lead, everyone hates you. And then you have eventually [UNINTELLIGIBLE].

AUDIENCE: There's also if he had a bunch of resources, like if you had a bunch of cities on a resource and if someone draws a six then you end up getting six resources from a tile then that's higher probability that if someone rolls a seven, [UNINTELLIGIBLE] So I guess that's negative feedback, too.

PROFESSOR: Well your going to seven and losing your cards mechanic is very much a negative feedback. I'm so rich! Now, I'm not so rich. What kind of poor is this, ha, ha. I still could have seen them [UNINTELLIGIBLE] That's negative feedback.

A couple of things about negative feedback to keep in mind is that negative feedback does tend to make games longer. It sort of staves off the ending of the game because obviously, the difference between the people in the lead and people not in the lead narrow it to the point that sometimes puts it back in connection again. And positive feedback tends to make things end sooner. OK, all right. Now, next team.

AUDIENCE: So in *Scrabble*, the main one we came up with was that if you play a long word, you get a lot of points and you also get a lot of tiles which gives you the opportunity the next turn to play more points and get more tiles played.

PROFESSOR: Oh, yeah.

AUDIENCE: There's also that the more tiles you play, the less tiles there are available. So that's kind of negative.

AUDIENCE: Yeah. It's both positive and negative. That was proposed.

PROFESSOR: Near the end, yeah, it becomes negative feedback. You possibly end up with just fewer tiles. That's true. Any other negative loops in there?

AUDIENCE: Well we tried to make it into a shot deal. Yeah, every time you play a bigger word it's easier for someone else to play a word off of that. That's negative feedback.

PROFESSOR: That's an interesting thing because that's actually counter examples to a point that was made by Eric Zimmerman. Because he argues that positive feedback actually magnifies early successes. And negative feedback tends to magnify big ones. Just like in Mario Kart, it's great to be the second place because if you do a late game success that propels you to first place just as the game ends. Whereas, some of the examples that we've been hearing on all the feedback, if you manage to be the first one to build a city in Settlers, that tends to perpetuate your success for the rest of the game.

The game isn't quite as predictable as that but it's designed that way, at least. But that's a very, very good example of you've got this negative feedback near the end of the game where you have a success by playing all of your tiles but the bag is almost empty. So now, you are not getting, not whether you are or not getting an advantage, that late game success isn't translating into [UNINTELLIGIBLE] Still, it's as a general rule, if you aren't dealing with a limited resource, like tiles, then we do this situation where a positive feedback game, a positive feedback loop is going to have to find early successes. And negative feedback make late successes more hard.

AUDIENCE: So we're basically, [UNINTELLIGIBLE] *StarCraft*. But I think with *StarCraft* was some of the obvious positive feedback is that the more a worker was built and then the more mineral you can get. The more mineral's gathered you can get more troops.

PROFESSOR: The more workers you build the more cash you get. The more cash you get the more workers you can build. That's [UNINTELLIGIBLE]

AUDIENCE: Another positive feedback loop is the more that you conquer your opponents, the harder it is for them to build up and finance you while the easier it is for you to beat them. On it the other hand do you want do negative feedback?

AUDIENCE: I don't think [UNINTELLIGIBLE]

AUDIENCE: The only thing with positive feedback is just like emphasized a lot of the earlier game strategy.

AUDIENCE: So a negative feedback loop in *StarCraft* would be the faster you, the more you expand your territories the harder it is for you to defend because your spraying half your resources, and the more friends you have, so the easier it is for your opponents to attack you.

PROFESSOR: Yeah. We were having that little discussion earlier and finding other negative feedback in this was kind of tricky, actually.

AUDIENCE: Another one that I thought of was the more research that you do, the less resources you have for building units or workers and such. And so you have to decide. I mean, your power will be units but you may have less to actually build those units. And probably not really it's a very small negative loop.

AUDIENCE: Another thing, too, the more shoots you have, the less attention you can give to all the [? children. ?] So it's harder to manage.

AUDIENCE: The less effectively use them.

PROFESSOR: The more different screens you've got to keep your eye on makes it

AUDIENCE: That's the great thing about the control wand. It's like one, go here. Two, go here. Three, go here. One thing a team gives, though, is there's a huge positive feedback. If you're doing 3D, if you take out one of them and then it's so much easier.

PROFESSOR: [UNINTELLIGIBLE]

AUDIENCE: Then you have a bunch of risk because what happens if you try taking out one person? Then, you fail and now you're weak but then they have a lot more troops.

AUDIENCE: So in keeping in comparison with *Warcraft III* which didn't have built in negative feedback where if your army gets past a certain size and it costs more, at least you can get taxed income. Yeah. I don't know if you guys know about this. But basically, think like *StarCraft* but then you have a food count that once you get past a certain food count, each of your peons brings in less gold from the farm. I'm sorry, from the gold mine. And it gets even worse the more troops you get. So you're kind of punished for being too far ahead.

PROFESSOR: That's a very key negative feedback.

AUDIENCE: This isn't a strict thing to keep up with but it's interesting to look at the resource management. Basically investing in units that bring in more resources or investing in other units that you're fighting are all different positive feedback loops. And you can view not investing as negative feedback loops in those areas. Although, it's not really completely true.

PROFESSOR: Yeah. are trying to think of that as negative feedback but you're right. They are different positive feedback groups. They work very differently. Winning a battle makes it easier for you to win later battles. But building more workers makes it easier for you to go more units.

AUDIENCE: Kind of in a not apparent positive feedback issue with *StarCraft* upgrading a Zealot's attack power by just one greatly increases its efficiency because now two attacks will take down a Zealot. Where before it would be three attacks

PROFESSOR: I don't want to get into that much detail. Let's go onto the next game. [UNINTELLIGIBLE]

AUDIENCE: So, let's just say, *Crunch* we can have a bigger workforce and they're returning to pay for that. So you get more money for your workforce but you still have to pay for that. That's negative feedback.

PROFESSOR: Yeah. That's a killer.

AUDIENCE: It turns out in *Monopoly* if you have a lot of money, and a lot of stuff, which people then land on, which gives you more money.

AUDIENCE: With what?

AUDIENCE: That's top secret secret strategy. I mean, *Monopoly* is to buy lots of stuff and then have people land on it so you can get more money.

AUDIENCE: So this one little negative feedback into, actually two, for the income tax and

AUDIENCE: repairs on property and the like.

AUDIENCE: So several thousand dollars to build hotels.

AUDIENCE: Our actual government is like that, too.

PROFESSOR: So it patterns out to real life but then again, so is the whole of the *Monopoly* game. The whole of the *Monopoly* game is about real life land ownership monopoly in Atlantic City, I believe. Yes.

AUDIENCE: It's Atlantic City.

PROFESSOR: So yeah. And that gives us a good segue into degenerate strategies. OK. All right. So I'll go into that a little bit. But maybe I'll get at what we did on Wednesday. But Wednesday we're going to focus that mostly on play testing your game. If we have no time for anything else, we are play testing your game.

And so bring in your games. Bring in your cards. Make sure your cards are ready before class. Don't be writing stuff. Try not to be changing stuff right up to another class. Sometimes you might be feeling the pressure to do that. Try to be ready before class starts. And try to show up right at the beginning of class. Because it will really, really suck if you finish play testing, if you finish play testing someone else's game and that team doesn't have enough time to play test yours. OK, and when it may happen and that will suck. So let's try to start that right on time next Wednesday. Thank you.