BLADE KOTELLY: What was the objective of the assignment? Charlotte?

AUDIENCE: To test your product.

BLADE KOTELLY: No. No. But I'm really happy you tested my product. That was great. That was not the objective of the assignment, though. Not 100%. Ben.

AUDIENCE: To see that design is everywhere.

BLADE KOTELLY: Yeah. That's part of it. To see that design is everywhere. So you can see all the things that people have done as well in terms of their critiques. Christy.

AUDIENCE: To start analyzing the design.

BLADE KOTELLY: To start analyzing the design. Absolutely. And what are you analyzing the design for? OK. We can do this. What are you analyzing the design for? Kenny.

AUDIENCE: Do you mean for what product are we analyzing the design or are you thinking why are we analyzing?

BLADE KOTELLY: Oh, let's talk about the why. Why are you analyzing design?

AUDIENCE: So we can incorporate what we're learning into things that we design [INAUDIBLE] and what we design ourselves.

BLADE KOTELLY: Yes. You're going to incorporate the things you're learning in terms of being able to do an analysis and work it in somehow to when you're designing. Isabella.

AUDIENCE: To understand effective and ineffective designs.

BLADE KOTELLY: Ah, to see what designs work and what designs don't work. Now this is interesting.

You used one product. There weren't two different products. You didn't say, well this was a good design, this was a bad one. You said, within one product, what was good and what was bad? Other reasons why we might have done it?

If you get really good at being able to critique other designs, you'll be able to be really good at critiquing your own designs. So what you'll do over the semester is learn a whole bunch about this. And at the end of the semester, I want you to look at the same video you've made and it see how you could make it better. Let's see what comes to mind about that. Do you have a comment, Joel?

JOEL SCHINDALL: No, just watching the answers.

BLADE KOTELLY: OK, so here--

JOEL SCHINDALL: But actually, I think whoever answered early in it-- an awareness of design so that as you go-- this course actually takes place not just in the two hours that you're here but in the hours in a week minus hours that you're here that you spend the rest of your lives. And we intend to project it out there and have you actually be aware during your life of what design is. That's what's going to make you a better designer.

BLADE KOTELLY: OK. So, we're going to get right into the meat of this. This is the 10-Step Design Process. This is the core of what we're going to be teaching. You'll use this process over and over and over again. It's a great process to know. You might find that it appears on pop quizzes. You might find it appears on pop quizzes.

And it might be something that if you wrote on a card and you put in your wallet and kept with you, you might be allowed to use on a pop quiz. Just saying. It might be on many pop quizzes. But it might not.

OK. So we start with these first beginning steps. Number one, we want to identify the needs and really understand the problem. In our last class I gave you a design challenge. So this is the first step, identifying the needs. What is the problem we're really trying to solve? And if we can get underneath that we can design something in a much more impactful way. So let's talk about this interesting example here.

I had a teacher as an undergraduate who designed a toothbrush. Now, I'll show you a picture. This is Napoleon's toothbrush. Napoleon Bonaparte used this toothbrush. A long time ago. If you bought a toothbrush in the '60s or something, you'd buy a toothbrush that looked like this. Does that look familiar to people? Yeah, OK.

He designed a toothbrush that looked like this. That's his design, the Reach toothbrush. Who's heard of the Reach toothbrush? OK. And there are a lot of different versions that they wound up making over time. But that's the early version of the toothbrush.

People brush longer and more thoroughly based on the design of the toothbrush alone-- with no instructions. Here's what happened. If you have a toothbrush and it's a flat head toothbrush like the one we showed you before here-- like that-- you hold it, you start brushing your teeth like this.

And you see people can do this all day. They can watch a sitcom with doing this to their front teeth, no problem. Very comfortable. But if they need to brush other parts of their mouth-- and they do-- they do this. They take this.

I'm going to represent the bristles with my thumb and hold the handle like this. They brush their teeth like this and then they get their rear molars like this on the side. And they want to get the upper rear molars on their sub dominant hand side. Which means they do this. Right? I'm writing, so I do this.

So everyone, if you're a righty, put your right hand up. If you're a lefty, put your left hand up. Take your hand, make a fist like that with your thumb out, curve your wrist over, and bring it across like that.

Now hold this. Is that comfortable? This is not a comfortable position for your arm to be in, right? OK. So as a result, people do this. And if you watch them do it, they do this and they go, ugh, they get bored. And they stop brushing. That's not good.

So this teacher, this professor I had, to understand this, he did some studies. He had people stain their teeth red. And then, with no mirror, he said, brush your teeth.

And people would brush it. And then he'd look inside their mouth and see the red was all of the front and all stuck in that part in the back. He said, that's no good. So he designed this thing.

In fact, there's a ton of innovations around this. Different handle. You see this side. Your thumb sits in that groove really easily. In fact, you'll turn that toothbrush 90 degrees and your thumb will rest right there. You do it automatically. You'll do it automatically like this. And this is thin over here at an angle. So it doesn't pull your cheek out like this . That's not very comfortable, right? OK. So he did that.

The head was shaped differently. Instead of doing a square head, it's now tapered, the bristles are shaped differently. So here's the question. What was the underlying problem he was trying to solve? Kristen.

AUDIENCE: The fact that people weren't able to reach their back teeth properly.

BLADE KOTELLY: That was a problem he was trying to solve but it wasn't the underlying problem he was trying to solve.

AUDIENCE: The fact that people didn't want to brush their teeth.

BLADE KOTELLY: The fact that people didn't want to brush their teeth. That's a problem that he was helping with but that wasn't the underlying problem. David.

AUDIENCE: People with bad teeth.

BLADE KOTELLY: People have bad teeth? People with bad teeth-- not the underlying problem. [? Cosi? ?]

AUDIENCE: The design of the toothbrush hadn't changed in a while.

BLADE KOTELLY: The design of the toothbrush hadn't changed in a while and we're getting closer now to the underlying problem. Because we saw that Napoleon had a toothbrush very similar to the toothbrush that you could buy in the '60s. A small difference though, his was they said silver-plated, I think. Anyone here own a silver-plated toothbrush? OK. Yes, Dennis?

AUDIENCE: The functionality of the toothbrush?

BLADE KOTELLY: The functionality of the toothbrush. He definitely wanted to change the functionality of the toothbrush but it wasn't the underlying thing. Louis?

AUDIENCE: Was it to simply build a better toothbrush?

BLADE KOTELLY: It was about building a better toothbrush but that's not the underlying reason. [? Shuni. ?]

AUDIENCE: An uncomfortable toothbrush was leading to poor brushing habits.

BLADE KOTELLY: Yes. But we're not getting to the underlying reason, what made him do this. Emily.

AUDIENCE: Was it low toothbrush sales?

BLADE KOTELLY: Well, interesting. It wasn't-- we're getting very close now-- it wasn't low toothbrush sales, per se. But by doing that he did make somebody happy by increasing the number of toothbrush sales.

AUDIENCE: People have loads of cavities back here?

BLADE KOTELLY: Oh, cavities. No, we're getting further away. Cavities is cooler. Sales is warmer. Patrick.

AUDIENCE: The ability to increase the price on the toothbrushes that are new?

BLADE KOTELLY: Increasing the price of toothbrushes that are new. That's interesting. Kind of. Kind of. It's actually-- they would have been happy if the toothbrushes were the same price.

AUDIENCE: I mean, but you're like, trying to get people to believe that it's worth what you're paying for.

BLADE KOTELLY: Yes. For what though? For this for that particular toothbrush.

AUDIENCE: Yes.

BLADE KOTELLY: Yes. It's a little bit-- it's a shade of meaning difference. I think your close.

AUDIENCE: To design the best toothbrush?

BLADE KOTELLY: Well, he definitely wanted to design the best toothbrush and he did at the time. But we're now getting colder. [? Cosi? ?]

AUDIENCE: So they can make money?

BLADE KOTELLY: Oh, to make money. Yes. To make money. Absolutely. For whom?

[INTERPOSING VOICES]

BLADE KOTELLY: For who?

AUDIENCE: For himself.

BLADE KOTELLY: For himself. No. He's a designer. Designers don't make much money, it turns out. Some do. Some designers make money. Not a whole bunch of designers make money. And they paid him a fee to do this work. They don't get residuals. Like if you make a movie and you're a famous movie star, you get residuals. Designers don't get residuals. They should. Definitely. Ben?

AUDIENCE: Stakeholders?

BLADE KOTELLY: Stakeholders. Yes, stakeholders, yes, that's kind of close. A little bit too far back. But if you tell me which stakeholders.

AUDIENCE: Company.

BLADE KOTELLY: Which company?

AUDIENCE: Did he just not like brushing his teeth?

BLADE KOTELLY: I don't think he cared about brushing his teeth. He was hired by a company who said, hey, John. We make blank. We want you to make something that's going to sell a lot of blank. Can you fill in the blank?

AUDIENCE: Toothpaste?

BLADE KOTELLY: Not toothpaste. That's a great idea. It's not toothpaste. Emily.

AUDIENCE: Is it the nylon, like the bristles?

BLADE KOTELLY: It is nylon. It is the bristles. Nylon is made by whom? DuPont. Nylon bristles started coming out in, I think, 1936. And they, DuPont loves to sell nylon. And they said, hey John, we want to sell a lot of nylon. Can you do something that going to help sell a lot of nylon?

And they asked him to do this. So what he did is he looked around the world and he said, what in the world is made of nylon? It's a lot of research just to figure out what's made of nylon. What hasn't been redesigned in a long time that's made of nylon that I could redesign? Hey, what hasn't been redesigned in a long time, that's sold all over the world, made of nylon, has existing manufacturing capabilities, so it's really easy to make a small modification that will sell a ton of nylon. Answer? Toothbrush.

So he made a toothbrush and he improved the design. And they made a tremendous number of changes to the toothbrush in the first design he made. And they kept releasing them slowly over time. So people get used to it, buy more toothbrushes, buy more nylon. Cool, right?

So understand the underlying reason. If you said, I want to sell-- if someone said to you, I want to sell a lot of nylon, it's hard to figure out what to do to sell a lot of nylon. And that was his approach. So what's the real problem here?

Information phase. What in the world exists that can inform us about this problem? So what kind of things might you do to understand a problem?

AUDIENCE: Google.

BLADE KOTELLY: You can use Google. Excellent. What else might you do to understand a problem?

AUDIENCE: Talk to people who are suffering from the problem.

BLADE KOTELLY: Talk to people. Do market research. Excellent. You might even look at adjacent problems. Problems that are not exactly the same. So if you're doing a toothbrush redesign, what other kinds of things might you look at to help inform you about how to design a better toothbrush? Emily.

AUDIENCE: Hair brush design.

BLADE KOTELLY: Hair brush design. Absolutely. Why?

AUDIENCE: Might have similar problems dealing with the product.

BLADE KOTELLY: Absolutely. What else?

AUDIENCE: Dental floss.

BLADE KOTELLY: Dental floss. So you might figure out what dental floss does well. In fact, there's a dental floss device that looks kind of like a toothbrush. It's got a handle. It's got a little small piece of floss and you use it like this. So that's another way of considering it. Excellent.

Stakeholder phase. This is really important. What's wanted and who wants it? Just because you can make it doesn't mean that people want it. Who knows what a VCR is? Great. This example won't work one day. OK. So here's the question. If I made a VCR, what functions would it have to have. I'll start you off. Play.

AUDIENCE: Stop.

BLADE KOTELLY: Stop.

AUDIENCE: Rewind.

BLADE KOTELLY: Rewind. And?

AUDIENCE: Fast forward.

BLADE KOTELLY: Fast forward. What else?

AUDIENCE: Eject.

BLADE KOTELLY: Eject. That's great because otherwise the tape is sitting stuck in there. Wow, it's an awesome tape I keep using. I've watched "Tron" 145 times.

AUDIENCE: Open.

BLADE KOTELLY: What is it?

AUDIENCE: Open.

BLADE KOTELLY: Yes, so we have an eject mechanism. Pause.

AUDIENCE: Power.

BLADE KOTELLY: Power.

AUDIENCE: Record.

BLADE KOTELLY: Power, yes.

AUDIENCE: Record.

BLADE KOTELLY: Record. That's great.

AUDIENCE: Some of them have the little displays with like the time.

BLADE KOTELLY: Yes. I need a flashing 12:00. Let's do flash 12:00. OK. So, a time. Why do we have a time display at all? Why was there ever a time display on a VCR?

AUDIENCE: So you know long is the tape.

BLADE KOTELLY: Well, yes. So we have some sort of a method. That actually is separate. To position the tape, I just use the counter. It might go up to a thousand or something-- or more. The counter might tell me a position of the tape. What'd the time tell me? Besides the time.

AUDIENCE: How long you've watched.

BLADE KOTELLY: It could tell me how long I've been watching it. It might allow me to do something.

AUDIENCE: Timed recordings.

BLADE KOTELLY: Timed recordings. I could not have to be home and I could set my VCR to record channel four-- because back then we only had five channels-- channel four and that would record that at 5:00 PM when I didn't get home till 7:00. Big deal. It was before DVRs. Amazing. What else?

OK. I like that list too. So, let's suppose I made a VCR and it had all these features on it but I took away one feature. I took away the ability for you to record. Show of hands, who thinks that's still useful? Who thinks it's useless. OK. Why is it still useful? A VCR that cannot record.

AUDIENCE: Because that ability is pretty-- it's decoupled from the other-- from the other functions.

BLADE KOTELLY: But why would I want a VCR that doesn't record?

AUDIENCE: So you can watch movies?

BLADE KOTELLY: So I can watch movies. When would I want to watch movies, but not be able to record things?

AUDIENCE: When you rent them.

BLADE KOTELLY: When I rent them. Or when I bring them to a ski condo or something. I go to someone else's place, we bring up videotapes and then people can watch the video tapes. Right? Great. And what's the benefit of not having that record head in the machine? Because it's a record head and a playhead.

AUDIENCE: It saves you a lot of money manufacturing.

BLADE KOTELLY: It saves you a lot of money manufacturing. You can pass that savings on to the consumer. Because these are two different objects. OK. What if I took out, instead of the record head, I took out the playhead. Who thinks that's useful? Who thinks it's

useless? You're all wrong. No, it's you're all right, in a certain way. Why do you think it's useless? I can't play videotape. Why is it useless?

AUDIENCE: Because you can record something. You can't watch it.

BLADE KOTELLY: As soon as I record something, I can't watch it. Kind of a weird thing to do, right? Oh, I can't wait to watch this thing when I get home. I've recorded it. Now what? I have no idea.

But think of it this way. What if I had a business and my business was a video duplication business. You gave me one videotape and I'd make thousands for you. You know at graduation they shoot people when they walk down.

[LAUGHTER]

BLADE KOTELLY: With a camera. They shoot people when they walk down and receive their diploma and they shake hands. So, they have you on videotape. And what if people want to order videotapes? They want to duplicate them. Or back when you used to buy videotapes, as a kid perhaps, you bought "Bambi" and you wanted to get a copy.

Well, there's some room where there's a machine and it plays. And there are thousands of machines that record. Thousands. They can record and rewind. They can do nothing else. They record and they rewind. And that's all they do. That's the whole thing.

And so it's a lot cheaper for people to buy thousands of those things without the playhead or fast forward or anything else. You can really make it a much less expensive product. So, just because you can do it and you can put it on there doesn't mean you should.

So, stakeholder phase is also a little bit bigger. Who are the possible stakeholders? We talked about this a little bit before. I think Ben brought it up, saying that the stakeholder can be shareholders or they could be people who are related to the design in some method, some aspect.

Whether it's-- in this class. Let's take this class, for example. Who are your

stakeholders in this class? Who's the primary stakeholder?

AUDIENCE: Ourselves.

BLADE KOTELLY: You. You're the primary stakeholder. Who's another stakeholder?

AUDIENCE: Parents.

BLADE KOTELLY: Parents. Why?

AUDIENCE: Because they're paying for it.

BLADE KOTELLY: Because they're paying for it. And they want to get some value out of that. Who else?

AUDIENCE: Staff.

BLADE KOTELLY: Staff. Which staff?

AUDIENCE: All of you guys.

BLADE KOTELLY: All of us. So we're all stakeholders.

AUDIENCE: You all want to see this class be a success.

BLADE KOTELLY: No. We want to see you be success. It's different.

AUDIENCE: Aww.

BLADE KOTELLY: I don't care about the class.

[LAUGHTER]

It's true.

AUDIENCE: I believe it.

BLADE KOTELLY: The class could be a massive failure, but if you're successful, and we've helped you do that, then we've been successful. That's our job, to make you successful. What

other stakeholders do you have?

AUDIENCE: MIT.

BLADE KOTELLY: MIT. How's MIT a stakeholder? What?

AUDIENCE: They're putting us on their CW so they get more attention to MIT--

BLADE KOTELLY: Well, maybe so they can get more attention or maybe so they can share the ideas with people who can't be in this room with all of you. So maybe there are two different stakeholders. Maybe there's people that want to get money from and say, look at this cool class! I hope they think it's cool.

Or maybe there are people who say, I really wanted to hear about that lecture that I can't get to. John's brother can't get to this lecture today. Wanted to. Can't do it. So he's a stakeholder as well of the recording. So lots of stakeholders and we'll be discussing this next class.

Now we do planning/operational research. What's realistic? What limits us? If we want to make something, what limits do we have whenever we make something?

AUDIENCE: Cost.

BLADE KOTELLY: Cost. Sure. What do you mean by cost?

AUDIENCE: The cost of manufacturing.

BLADE KOTELLY: The cost of manufacturing. What about software? Does it cost anything to manufacture software?

AUDIENCE: Yes.

BLADE KOTELLY: What does it cost?

AUDIENCE: Time.

BLADE KOTELLY: For the-- well, yes. Let's call that the design development portion. But how about the manufacturing of it? Because if I manufacture toothbrush, I've designed and

developed it and now I could have machines that are stamping out toothbrushes and putting bristles all on stuff. How about software? Any cost of software?

[INTERPOSING VOICES]

A lot less. There is a cost, though. Because I gotta pay somebody to host it and somebody to-- every time you download software, it costs a little bit of money and that begins to add up. So yes.

AUDIENCE: Cost of memory--

BLADE KOTELLY: Absolutely. Yes. So there are costs involved that can limit us. What else?

AUDIENCE: Time.

BLADE KOTELLY: Time. What kind of time?

AUDIENCE: When you're in the-- basically any stage, you have a certain amount of time to get this done, so you've got deadlines to meet. Plus, if you're paying people to work for you, the longer they're working on it, the more that turns into money later.

BLADE KOTELLY: Yes. So there are lots of costs involved. I'm sorry, lots of time costs involved. So the time it takes for something to be executed upon to the time we have to execute it.

In classes, you're often limited by time. If you had an infinite amount of time, you could learn the material much more easily, probably. What else are we limited by?

AUDIENCE: Finite amount of raw materials.

BLADE KOTELLY: Materials, right. And materials can come in a lot of versions. Resources can be physical resources, they can be people resources, they can be environmental resources that we have access to. Anything else?

AUDIENCE: Technical capabilities.

BLADE KOTELLY: Abilities. Knowledge. We can be limited by knowledge. So we have a team-- a brilliant team. You're all brilliant people. Who here knows the process of opening a

restaurant that's successful? OK. So right now we're limited by a certain level of knowledge.

If we all decided to open a successful restaurant tomorrow, but you are all brilliant people, so maybe we could figure it out very quickly. Maybe not. Maybe we'd find someone who's already opened a successful restaurant to let us know all the things we should know and short circuit that amount of failure time we have.

OK. So, from there we go into a hazard analysis. And we're thinking about here, what's safe? Or what can go wrong? So in classical design, let's say it's a baby's high chair. I might say, well, if the baby can slip underneath the high chair, that's not safe. So you gotta keep that from happening.

If I'm designing a stock trading system, where online you get to buy stock or maybe call over the phone. You say, buy 100 shares of Microsoft at the market price. What could go wrong?

AUDIENCE: Fraud.

BLADE KOTELLY: Fraud. What kind of fraud?

AUDIENCE: Someone impersonates someone else

BLADE KOTELLY: So we have a security issue there. We don't know if you are you. What else can go wrong?

AUDIENCE: In terms of how you design the website or whatever else-- the interface-- if it's really easy to make mistakes. Say, an extra zero somewhere.

BLADE KOTELLY: Yes. What if I put a number in and I don't put the dots and I have two zeros. It's a bit more than a rounding error. In fact, a friend of mine just made a piece of software where you can pay-- you walk into a restaurant and if they have the software running, you can walk in to say, I'm here at the restaurant.

And then when you want to leave, if a bunch of you are all eating together, so we're all eating and we want to split the bill differently, and he ordered something, the very

expensive caviar, and she ordered the very expensive champagne, and she ordered the very inexpensive fries, and she ordered the somewhat moderately expensive chicken, and I didn't order anything. Well, we want to split the bill somehow.

Well, they make it very easy to do it. But they were just testing it in real life and for a server, the server came over said, let me see how to do this. And he said, sure let me show you. The server entered in the numbers for how much we had. But it came out to a huge number. Much more expensive. 100 times more expensive. Because servers, on these point of sale systems that they press in, they don't enter the decimal point. Because it's faster to just type in the numbers and enter two zeros.

So his system required that you enter a decimal point. And he realized, oh, gotta change that behavior. So what can go wrong. We think about in this hazard analysis, which is lots of things.

And so when you're designing something, you want to think of what can go wrong. In software, we have bugs. Bugs can go wrong and we try to mitigate for that. In physical design, it can be unsafe. Someone's hand could be caught something. They could pinch their hand. It could cause injury.

From that, we do a specifications phase to really sit down say, OK. What is required? What's required of this design without any specific instructions of how to design it? What's required? So in this phase, we really sit down to figure out what we need to do. But we haven't said what to do yet.

We go on to creative design. Who here knows how to brainstorm? Who here does not know how to brainstorm? OK. Brainstorming is really important and we'll talk about this a little bit later. How you brainstorm is important as well.

This is the part where we begin to think about all the different things that are possible. And if you're working with a good team or people you like a lot, it's easier to come up with really interesting ideas. They may be terrible ideas but they may be very interesting. And that's OK.

From there, we start narrowing down to conceptual design. What are the potential solutions that we can make? So we might have a few different ones that look pretty good. But they may not work together. We might say look, we go down one path, we can't go down the other path. They are mutually exclusive. Or if we try to do both paths, they're very hard to do together. So we narrow down the concepts and then we say, OK, we're going to pick something.

At this phase, you might just say, let's pick whatever one we want to. Or you might have a process for picking a design. You might ask experts to help you pick which approach to take. You might do market research. You might do a whole bunch of other things to figure out which one you prototype.

And lastly, the last step is verification. And I don't mean quality assurance. I don't mean does it work to the specification. Of course we expect it to work as we want it to work. But I mean, do people like? Can they use it? Do they want to use it? Is it emotionally and intellectually compelling? Does it makes sense? Does it connect with people on these two levels?

And that goes right down to very small things. To parts and cars. Goes to things that are consumer products and things that are less obvious in terms of being consumer products. And we have an end solution but is it an end solution, really?

What solutions or products do you know that cannot be improved upon? Any ideas? That's pretty good. Maybe there is something out there. But I like the idea that we can improve on anything. So end solutions mean if there's more room for improvement, we go back and do the whole process all over again.

Let's map this to cooking dinner. Who here has cooked dinner? Who has never cooked anything in their life? Ah, it's worth cooking. You'll like. It will make you less hungry. So let's start off. We're going to identify the needs. What is the underlying reason that we cook dinner?

AUDIENCE: Hunger.

BLADE KOTELLY: Hunger. Because we're hungry. What other underlying reasons could there be for

cooking dinner?

AUDIENCE: Other people are hungry.

BLADE KOTELLY: Other people are hungry, yes.

AUDIENCE: Could be a social occasion.

BLADE KOTELLY: A social occasion.

AUDIENCE: To stay alive.

BLADE KOTELLY: To stay alive, yes. Maslow's hierarchy here.

AUDIENCE: Not to take the dining plan.

BLADE KOTELLY: To avoid a required dining plan, you need to cook. OK. What else?

AUDIENCE: To win or earn money.

BLADE KOTELLY: To win or earn money. Do you mean, on a TV show? Fantastic.

AUDIENCE: I like cooking.

BLADE KOTELLY: You like cooking. It's an enjoyable experience. It's fun to do. It's creative. What else?

AUDIENCE: Boredom.

BLADE KOTELLY: Boredom. I'm bored. What should I do? Watch TV? No. Play video games? No. Cook? Great. Why else would we cook?

AUDIENCE: To come up with new dishes.

BLADE KOTELLY: To come up with new dishes. To create, to innovate on dishes. What else?

AUDIENCE: To impress someone.

BLADE KOTELLY: To impress someone. Who might you want to impress?

AUDIENCE: Boyfriend or girlfriend.

BLADE KOTELLY: Ah, a date. A boyfriend or girlfriend. Great. Jackie. OK. So Jackie has a date. And she's identified the needs. She's gotta impress her date. We go on to an information phase. What in the world can help Jackie determine how to impress her date?

AUDIENCE: What does he like to eat?

BLADE KOTELLY: Ah, yes, so she's lost her voice here. And she said, what does he like to eat? Right. What does the date like to eat? Right. That's what we want to find out. So we're doing market research to that point to figure out the preferences of our target audience. Emily.

AUDIENCE: What the date's allergic to?

BLADE KOTELLY: What's that he's allergic to? I would put that in step number five.

AUDIENCE: Food in season?

BLADE KOTELLY: Ah, food in season. Yes. We could be informed by what food is in season. And how would we find out what food is in season?

AUDIENCE: Grocery store or look online?

BLADE KOTELLY: You can go to the grocery store. Now, tomatoes. Have you ever not been able to find a tomato at your grocery store? But they're not in season very long. So the question is, if you want to get something that's in season and local perhaps, you can go to grocery stores, you could look online.

AUDIENCE: Farmers market.

BLADE KOTELLY: A farmer's market where the farmers who are local come over there and they'll let you know, we've got lots of kohlrabi. Rabi Who here has ever used kohlrabi? Who's ever heard the word "kohlrabi?" OK. So it's one of those things that farmers' markets have lots of. What else?

AUDIENCE: What's affordable?

BLADE KOTELLY: What's affordable. I might put that under our planning research and operational research there. Jackie.

AUDIENCE: What do you know how to make?

BLADE KOTELLY: What do you know how to make. Knowledge. That's what would be limited by in planned research. But what else can inform our decision can also be that. Which is, I happen to make these four things really well. So, that's part of my research. What else? What else might we look to, to help us with planning a date for Jackie?

AUDIENCE: Whether he or she is vegetarian or not.

BLADE KOTELLY: Whether the date is vegetarian or not could inform us. So some market research.

AUDIENCE: What kind of date it is.

BLADE KOTELLY: Ah, the kind of date. We're going back to step one. Tell me about this.

AUDIENCE: It could be a very important occasion as far as like engagement. Or it might be like a first date.

BLADE KOTELLY: A first date, an engagement. And they might be different. So the first date may not have caviar and a diamond ring. It might. Might be pushing it a little bit much, if you want the date to go more than five minutes. OK. So, yes. So first day and an anniversary date might be very different.

AUDIENCE: What tools you have to cook with?

BLADE KOTELLY: Tools you have to cook with. Yes. I might put that again under planned research but information phase as well.

AUDIENCE: What Jackie likes to eat.

BLADE KOTELLY: Ah, yes, what you want to yourself. Jackie enjoys pasta and hates hamburgers. What about some resources that are available for research? Ann.

AUDIENCE: You can get a cookbook to see what types of foods go well together.

BLADE KOTELLY: Cookbooks. Absolutely. And she said to look at cookbooks to see what kinds of foods go well together. Most cookbooks don't tell you this. Interestingly, most cookbooks tell you how to cook a specific dish, but don't tell you what to cook it with.

Some very good cookbooks do. I recommend Mark Bittman if you're cooking and you're in college. It's a great cookbook and tells you what to pair with it. What did you say? I heard something else.

AUDIENCE: The internet.

BLADE KOTELLY: The internet. Absolutely. And what might we Google?

AUDIENCE: The price of stuff at stores, recipes, what goes good with it, everything.

BLADE KOTELLY: So we have we have recipes we could Google, the price of stuff at the store. Let's bring up Google for a second here. OK. So, let's bring this over and type in, price of stuff at the store. Just slide it over-- Great. And slide it over to the right a little bit, please.

[LAUGHTER]

Jackie. Do you like beer? Like beer, Jackie? Because if you do, this is a great thing to Google? OK. What else might we Google? Thomas.

AUDIENCE: What does my date like to eat?

BLADE KOTELLY: Let's Google what does my date like to eat? On the board, 100 people surveyed, top answers. 10 foods you should never eat on a first date. Phenomenal. The person's not sure if they can eat chorizo that is still not expired for another month. I'm glad they posted it on here and it's the second result. What else should we Google?

AUDIENCE: Delicious food that's easy to cook.

BLADE KOTELLY: Delicious food that's easy to cook. It's auto completing. This is great. Which I guess, John has already been to. John is in charge or does a lot of work with the food at his fraternity house, and that makes a lot of sense. What else might we Google for what you should cook on a first date. How about, what should I cook on a first date? I have no idea what's going to come up.

AUDIENCE: Be careful. Be careful.

BLADE KOTELLY: Actually, go back to what should I cook on. Let's go back to what should I cook on. And hit space. A, letter A. Romantic dinner, first date, and date come up at the top three suggestions by Google. That's pretty cool.

OK, let's go back to that slide, please. Yes. So this is pretty cool. OK, we're getting a lot of information right now from Google.

And we're up here to stakeholder phase now. Who are the stakeholders involved?

AUDIENCE: Jackie.

BLADE KOTELLY: Jackie. Who else?

AUDIENCE: Her date.

BLADE KOTELLY: Her date. Who else might be stakeholders involved?

AUDIENCE: People that sell food.

BLADE KOTELLY: People that sell food, absolutely. Yes.

AUDIENCE: Her parents.

BLADE KOTELLY: Her parents. If they don't like Jackie's date at all. Make the pineapple upside cake. But mom, I can't make that. Make the--

AUDIENCE: Maybe anybody that shares the kitchen with Jackie. People sharing the kitchen. There could be other stakeholders because maybe Jackie lives with other people. And she's like, hey can you be out of the kitchen tonight? I'm Like, no, I've got a

really important date. I'm making dinner. Two people making dinner dates at the same time.

BLADE KOTELLY: OK. Planned research. What could we be limited by? What could Jackie be limited by?

AUDIENCE: Cost.

BLADE KOTELLY: Cost. Right. So maybe the beluga caviar is prohibitively expensive for the date. Daniel.

AUDIENCE: Experience.

BLADE KOTELLY: Experience. Cooking experience. I can boil water but I can't make a bechamel sauce. OK.

AUDIENCE: Equipment.

BLADE KOTELLY: Equipment. Yes. I have a pot to boil water in but do not own a toaster. Making toast is harder. Not impossible, but harder. Yes.

AUDIENCE: Time.

BLADE KOTELLY: Time. Oh my god, the date's in half an hour. I haven't started dinner. I haven't been to the store. Calling Dominoes. OK. What else could you be limited by.

AUDIENCE: Her date's dietary restrictions.

BLADE KOTELLY: Yes, and I like that, actually, dietary restrictions in that phase. Stephanie.

AUDIENCE: Ingredients that you can't find at the store.

BLADE KOTELLY: Ah, yes, ingredients that you can't find at the store. So sometimes certain-- you have to go to special markets to find certain kinds of special spices or something else. And if you can't get that at your local store, then you may not be able to get it all. Or maybe you have to fly it in or mail order it or something. OK. This is good.

Hazard analysis. What could go wrong when cooking dinner for a romantic evening?

Rod in the back.

AUDIENCE: Allergies, food poisoning.

BLADE KOTELLY: Allergies and food poisoning. Should she cook the chorizo? I don't know. Looks kinda iffy. Allergies, yes.

AUDIENCE: Faulty equipment. If you have a bad stove.

BLADE KOTELLY: Yes, faulty equipment could cause a fire or something. That's really bad.

AUDIENCE: Setting the entire chicken on fire.

BLADE KOTELLY: He sounds like he speaks from experience.

AUDIENCE: Personal injury.

BLADE KOTELLY: Personal?

AUDIENCE: Injury.

BLADE KOTELLY: Injury, yes. So when cutting onions, look at the onion and don't try to make cool eyes. Stop. Bleeding is not considered cool on a date if you can avoid it.

AUDIENCE: Quantity of food.

BLADE KOTELLY: Yes, quantity of food, absolutely. This is a very real issue that really happens on dates. I'll tell you a story when I'm not on camera sometime.

AUDIENCE: Your date doesn't show up.

BLADE KOTELLY: Oh, yes. She's not speaking from experience. But yes, the date doesn't show up. That is sad. That can be a very sad thing.

AUDIENCE: Or you have a pset due the next day.

BLADE KOTELLY: Or you have pset due the next day. Not a good day for a romantic evening. What else?

AUDIENCE: Forgetting to set a timer.

BLADE KOTELLY: Yes. That's an easy thing to go wrong-- not setting timers. Yes. In fact, yesterday I did not set a timer. I put a thermometer inside the chicken and I said, great, when the thermometer reads 162, I'm going to pull the chicken out, no problem.

I proceeded to enjoy the company my friends and drink the wine and went, oh my god, came back over here, went oh, 175. Darn it. Yes. I should have set a timer. That would have been helpful.

AUDIENCE: Unlabeled food ingredients, such as salt and sugar.

BLADE KOTELLY: Confusing two similar in appearance ingredients like salt and sugar. Thomas sounds like he speaks from experience in this one. Yes. Not so good in coffee, salty coffee. But I believe popular in some places.

AUDIENCE: [INAUDIBLE]

BLADE KOTELLY: I'm sorry?

AUDIENCE: Fire drills.

BLADE KOTELLY: Fire drills. Something's that are a little bit beyond your control. OK. So this is good. Good hazard analysis for that.

Specifications. From there, we try to figure out what we're going to do. We might make a shopping list. We might make a list of what we're doing for the recipes. We go on to design it. And then we have to figure out, do people like it or not? Verification. How do we test to figure out if people are going to like it or not? Ben.

AUDIENCE: Take a small bite.

BLADE KOTELLY: Take a small bite. Take many small bites. Over the course of the meal, they say a good cook keeps tasting it before you serve it. What else could you do?

AUDIENCE: Get someone else to taste it.

BLADE KOTELLY: Get someone else to taste it, yes. When? Do you say, psst, come over here, John, come over here, I'm about to serve it to Jackie. No, when? At the time?

AUDIENCE: Earlier.

BLADE KOTELLY: Earlier. How much earlier? An hour?

AUDIENCE: Enough so you have time to fix it.

BLADE KOTELLY: Enough time so you could fix it later. What else could you do?

AUDIENCE: Call mom and ask if it's supposed to be brown.

BLADE KOTELLY: Mom, the chorizo's not looking very good. Yeah. Purple, green, yeah. Use it? OK.

AUDIENCE: You could, if you wanted to, do like a practice dinner beforehand.

BLADE KOTELLY: Ah, yes. A practice dinner beforehand. Let's see if you can make this stuff and how it tastes and if you like it. That's exactly right. OK.

So I've given you a design process that I'll tell you, you can use for making anything-- anything you ever make ever, ever, ever, ever, ever, ever, ever, ever, ever, ever, ever-- ever. In all your engineering disciplines, you can use this exact same process all the time for anything you want to make. We've got it to cooking dinner.

Let's have you try it on your own. Let's try this. Here's your design challenge. Map the steps of throwing a surprise party for your best friend. You're going to map the first five steps. I want you to work in groups of three-- the people in your vicinity. I'm going to give you about five minutes to do this. First five steps as completely as you can to throwing a surprise birthday party for your best friend. Here we go.

All right, so right now the students are trying to figure how to map the steps to throwing a surprise birthday party for their best friend. And they'll take about five minutes to do this. Over those give minutes, they'll try to map each of the steps individually. And we're going to do a debrief and figure out what they said. But now,

if you want to, try doing it yourself and see if you can come up with a really good solution. And see if they get some ones that you don't get.

All right, let's find out what you said to solve this problem. So you've had five minutes to try to figure out how to solve the first five steps of this problem. To figure out how to throw a surprise birthday party for your best friend. What is the underlying problem that we are trying to solve?

AUDIENCE: They don't have plans for their birthday and we want to make it awesome.

BLADE KOTELLY: She said we don't have plans for the birthday, and we're trying to make it awesome. Or they may have plans for the birthday and we're still trying to make it awesome. What are the other aspects of the underlying problem?

AUDIENCE: It's a surprise.

BLADE KOTELLY: It should be a surprise. Stated in the problem statement but also true. What else? Underlying problems, underlying objectives.

AUDIENCE: Throw a fun party for all those involved.

BLADE KOTELLY: To throw a fun party for those involved. Let's talk about those involved-- who are they? Anybody. In the back.

AUDIENCE: And the actual person whose birthday it is.

BLADE KOTELLY: And the actual person whose birthday it is, yes. What else? That's it? No other reason to throw a birthday party?

AUDIENCE: So that you get one later on.

BLADE KOTELLY: Ah, it's for you to get one later on. In psychology, we call it the reciprocity effect. Good. OK. So, we've identified the needs. Information phase. What can inform us about how to throw a surprise birthday party?

AUDIENCE: How old they're turning?

BLADE KOTELLY: How old they're turning? What do you mean by that?

AUDIENCE: Probably don't throw a clown party for a 50-year-old.

BLADE KOTELLY: You don't throw a clown party for a 50-year-old. I happen to know some 50-year-olds who might enjoy that, but it'd be kind of weird, right? OK. So maybe you do. Gotta pick your 50-year-olds very carefully. [? Affinity? ?]

AUDIENCE: When their birthday is. When their birthday is.

BLADE KOTELLY: When their birthday is would inform it, absolutely.

AUDIENCE: Just a quick question, does surprise party automatically mean it's a birthday party?

BLADE KOTELLY: This is a surprise birthday party. I'm sorry, yes. In this case it did. I didn't put that on the slide. Yes, you're right.

AUDIENCE: When they're free.

BLADE KOTELLY: When they're free would influence it, absolutely. What else can inform us about throwing a surprise birthday party?

AUDIENCE: If they like surprises or not.

BLADE KOTELLY: If they like surprises or not absolutely will inform us about how to throw a surprise birthday party for someone who doesn't like surprises.

AUDIENCE: What they like to do.

BLADE KOTELLY: What they like to do. For example?

AUDIENCE: If they like to go out bowling or something, you can throw a surprise birthday party.

BLADE KOTELLY: Right. To appeal to their hobbies and likes. Great. What else?

AUDIENCE: What kind of friends they have.

BLADE KOTELLY: What kind of friends they have. How do you mean that?

AUDIENCE: It informs who we're going to invite to the party.

BLADE KOTELLY: Informs who we're going to invite, yes.

AUDIENCE: Size and nature of the social circles. So you could have small gatherings or big gatherings.

BLADE KOTELLY: Yes. So how big the party should be. What else could inform us?

AUDIENCE: Past parties that you have been to.

BLADE KOTELLY: Past parties you've been to. Personal experience, where you say, this was an awesome party. This party sucked-- we are not going to do one of those again. Right. Absolutely, past experience is hugely important.

AUDIENCE: What can you do to distract them?

BLADE KOTELLY: What can you do to distract them. How do you mean?

AUDIENCE: You have to trick them into showing up in a room full of people at some point. You need a plan.

BLADE KOTELLY: You need a plan, yes. OK, good. So that's information phase that can inform us about it. But we forgot one of our most valuable tools that we talked about before.

AUDIENCE: Google.

BLADE KOTELLY: Google! And what might you Google?

AUDIENCE: How to throw a surprise party. [INTERPOSING VOICES]

BLADE KOTELLY: How to throw a surprise party. And do you think you'd get any results? A ton. You'd get a ton. Google has all the information that would appear. OK.

Stakeholder phase. Who are the primary stakeholders?

AUDIENCE: Guest of honor.

BLADE KOTELLY: Guest of honor.

AUDIENCE: Everyone invited.

BLADE KOTELLY: Everyone invited.

AUDIENCE: You.

BLADE KOTELLY: You. Who are secondary stakeholders?

AUDIENCE: People who live in the place you're hosting.

BLADE KOTELLY: The many people who live in the place you're hosting, the neighbors that call the cops all the time, and therefore the cops are also stakeholders. OK. Planned research, operational research. What are we limited by?

AUDIENCE: Money.

BLADE KOTELLY: Money! Great. So if we don't have a lot of money, we can't buy the expensive beer. What else?

AUDIENCE: Again, time.

BLADE KOTELLY: Time. When's their birthday? Tomorrow. No way. Tomorrow. What am I going to do? Going to throw a surprise birthday party in one day is going to be really hard to do. Right. OK. How much time do have exactly. What else?

AUDIENCE: Your best friend's schedule.

BLADE KOTELLY: Your best friend's schedule. Yes, because they could be traveling or our of the country or working night shifts or something like that, right. OK. What can go wrong at a surprise birthday party for your best friend? Veronica.

AUDIENCE: The person doesn't show up.

BLADE KOTELLY: The person doesn't show up. Absolutely. David.

AUDIENCE: Person finds out ahead of time.

BLADE KOTELLY: The person finds out ahead of time.

AUDIENCE: None of the guests show up.

BLADE KOTELLY: None of the guests show up. It's you and the person, you're like, surprise.

AUDIENCE: Going back to the cops.

BLADE KOTELLY: Going back to the cops.

AUDIENCE: Having them come.

BLADE KOTELLY: Having the cops come. Yes. Ben.

AUDIENCE: If you scare them into heart attack.

BLADE KOTELLY: Yes. You don't want to scare your friend if they have a heart condition. That's good. Cameron was that yours?

AUDIENCE: Yeah, weather.

BLADE KOTELLY: Weather. So don't have an outdoor party when it's going to be threatening to have a thunderstorm. Or in January in Boston. Not a good time for an outdoor barbecue-- just isn't. Kristen.

AUDIENCE: You accidentally send someone to the wrong location.

BLADE KOTELLY: Ah, yes, someone goes to the wrong location. Thomas.

AUDIENCE: You have invited some people that your friend is on bad terms with.

BLADE KOTELLY: Ah, yes. The old ex-girlfriend issue. I thought you were together. We haven't been together for months. I didn't know that. So I'll tell you a little story.

So my best friend in high school-- we're best friends and I'm throwing him a surprise birthday party. And my best friend was notorious for not showing up to things. You make plans a week ahead of time, you confirmed a few days ahead of time, it's Friday night-- ghost town. Just not there. And no one knows where he is. He just

was kind of casual. This happened all the time. And we all knew this.

I said, OK, I'm going to make sure he shows up. So I said, look-- he's really into art and design-- there's this great exhibit coming up for an M.C. Escher thing they're doing at this museum in Boston. And there's someone speaking and I'm going to buy tickets to it for your birthday and they're really expensive so can we clear the date, make sure it's OK. He goes, yeah, it's fine. Great. So it's like two months out. Two months.

So a month later, I'm like hey, looking forward to that exhibit thing? He goes, oh, yeah. Do you have it in your calendar? I do have it in my calendar. It's like the only thing he had in his calendar. It's good. It's now like a week out. Hey, dude. Next Friday we're going to the M.C. Escher exhibit. Right on. It's great. Perfect.

It's Monday. Hey, Friday night, we'll get together like 6:00-ish, we'll go and get some dinner or something. Then we'll go-- yeah it sounds great. Cool. Great. Wednesday. Got two days. Two days away! Cool. Right on. Thursday. Tomorrow!

Friday night, 6 o'clock, his house. I go there, what happens?

AUDIENCE: He's not there.

BLADE KOTELLY: No, he's there. It's amazing. I'm blown away. I'm like, he's actually there. Incredibly cool. So we do our whole thing. We go. We go to the thing. We go to the house. We walk inside, open the door. I go around the side of the door. Everyone's waiting here. He comes up around the door, everyone goes, surprise! And he's like, what?

I said, dude it's your surprise birthday party. Surprise! And he's like, I thought we were going to an exhibit. No, no, that was all fake. But you bought the tickets. No, they're not real. And he was sad. What we learned from our hazard analysis, our post mortem, don't make the other event sound more fun than a surprise birthday party. OK. All true. Next.

So, I've said you can map this to anything. Well, let's be a little bit more serious here. A little more serious about the engineering aspect here. You have four

minutes now to map it to this. Making a car fueled by a nuclear reactor. Same groups. Four minutes. If you happen to be a nuclear engineer, you have a head start.

OK. Right now, they're doing the same exact thing except for they're mapping something more engineering based. And the idea is that they can start to apply something that seemed very easy and informal to something a little bit more of their engineering curriculum. It's not a big stretch in this case here.

They're going to get lots of practice throughout the whole semester being able to apply this to a variety of different environments and produce things using this process. But here I wanted to show that there's a mapping that exists between stuff that seems very unrelated to engineering, like throwing a birthday party, and some very engineering related. Let's see what they come up with.

All right. Let's find out what you thought about how to solve this problem. Mapping the steps to making a car fueled by a nuclear reactor. What is the underlying objective? Or what could the underlying objective be?

AUDIENCE: Finding a new means of fuel.

BLADE KOTELLY: Different fuel.

AUDIENCE: Building a car that never needs to be refueled.

BLADE KOTELLY: A car that never needs to be refueled.

AUDIENCE: Cleaner energy.

BLADE KOTELLY: Cleaner energy.

AUDIENCE: Job market for nuclear engineers.

BLADE KOTELLY: A job market for nuclear engineers. That's very good. I like that. What else?

AUDIENCE: Faster car.

BLADE KOTELLY: Faster car. Zoom! What else?

AUDIENCE: Cleaner for the environment.

BLADE KOTELLY: Cleaner for the environment. Yes. What else? OK. Step number two, what can inform us about how to build-- where might we look to understand about how to build a car fueled by a nuclear reactor?

AUDIENCE: Other vehicles fueled by nuclear reactors, like submarines.

BLADE KOTELLY: Like submarines that are fueled by nuclear reactors, yes. Understand how a submarine works. Jackie.

AUDIENCE: Current car designs.

BLADE KOTELLY: Current car designs could inform us about what we could do.

AUDIENCE: How you could research possible nuclear accidents.

BLADE KOTELLY: Ah, look at nuclear accidents. I'm going to put that under the hazard analysis section. But yes, absolutely. Charlotte.

AUDIENCE: Small module nuclear reactors.

BLADE KOTELLY: Small?

AUDIENCE: Module.

BLADE KOTELLY: Module nuclear reactors. She knows a little bit about this.

AUDIENCE: I just got hired to work them.

BLADE KOTELLY: She got hired to work on them, great. You could actually research the thing that you might want to use.

AUDIENCE: Professors.

BLADE KOTELLY: Professors. Yes. You could talk to professors who deal with these things.

AUDIENCE: What regulations exist on nuclear reactors in cars.

BLADE KOTELLY: Regulations about nuclear reactors in cars or other kinds of transportation.

AUDIENCE: Find out what aspects of cars people don't want to change.

BLADE KOTELLY: What aspects of cars people don't want to change. Sure.

AUDIENCE: Who will want to use it.

BLADE KOTELLY: Understand the potential market of people who might want to have a car that never needs refueling, Stakeholder phase. Who are the stakeholders? Ben.

AUDIENCE: Everyone who's Course 22.

BLADE KOTELLY: Everyone who's in nuclear engineering. Who else?

AUDIENCE: NRC.

BLADE KOTELLY: The NRC who are the--?

AUDIENCE: Nuclear Regulatory Commission.

BLADE KOTELLY: Nuclear Regulatory Commission. So, government. Government. Who else?

AUDIENCE: Everyone within a 50-kilometer radius.

BLADE KOTELLY: Everyone in a 50-kilometer radius of you driving your car. Rod.

AUDIENCE: Oil companies.

BLADE KOTELLY: Oil companies. Yes, they are a stakeholder. Absolutely. Yes. Because if you have a really great car that doesn't need to be fueled ever, they're like, excuse me, pardon me, would you mind not making that?

AUDIENCE: Countries that mine uranium.

BLADE KOTELLY: Countries that mine uranium. So, they're definitely stakeholder because they've got

uranium. Dale.

AUDIENCE: If we haven't said it already, car manufacturers.

BLADE KOTELLY: Car manufacturers. Yes. Who else? We haven't said one particular constituent group that I think are very important in this particular calculus. Maybe not.

AUDIENCE: Mechanics.

BLADE KOTELLY: Mechanics. Wow, yes. Boy, how do you fix that? No idea. Why not? Didn't go Course 22. Really? What'd you do? Course 18. What else?

AUDIENCE: You.

BLADE KOTELLY: Yes.

AUDIENCE: The nature of the fact that you're designing them.

BLADE KOTELLY: The designer. Or the person who's the consumer.

AUDIENCE: Anyone who buys a car.

BLADE KOTELLY: Anyone who buys a car. Right. Absolutely. Anyone who buys a car-- electric cars, non-electric cars. Anyone else? That's a good list. Planned research. Operational research. What are we are limited by?

AUDIENCE: Fission or fusion.

BLADE KOTELLY: Ah, the choice between fission or fusion.

AUDIENCE: Current roads and whether we can have nuclear reactors on them.

BLADE KOTELLY: Yes. Whether we can actually have this on our current infrastructure. David.

AUDIENCE: Disposable spent fuel.

BLADE KOTELLY: Disposable spent fuel, yes. Charlotte.

AUDIENCE: Have to have low enriched-- you'd have to have low enriched uranium. You can't

have highly enriched uranium.

BLADE KOTELLY: OK. So we're limited by our ability to get low enriched uranium. Yes. I'm glad we have you here.

AUDIENCE: What's the cost of making them?

BLADE KOTELLY: Cost. Absolutely. The cost of making a nuclear powered car. Jake.

AUDIENCE: Different laws on street legal vehicles.

BLADE KOTELLY: On?

AUDIENCE: Street legal vehicles.

BLADE KOTELLY: Yes. Government laws on street legal vehicles and what you can and can't do with a vehicle to begin with. [? Yu? ?]

AUDIENCE: Price that people are willing to pay for a car that doesn't refueling.

BLADE KOTELLY: Yes. What would you pay for a car if it never needed fuel ever again? It's a good question, right? Would you pay a million dollars? No. Do you think you're paying a million dollars now in gas over the course of your life?

AUDIENCE: Your car won't last that long.

BLADE KOTELLY: Your car won't last that long. OK. Foiled again. What else?

AUDIENCE: Whether people would buy it because it's a nuclear reactor.

BLADE KOTELLY: Whether people would even buy it. It's nuclear reactor. I don't want to get that car. But it never needs fuel again. I don't want that car. Well, why not? Because I don't want to glow, I don't know. What else are you limited by?

AUDIENCE: How available the raw materials are.

BLADE KOTELLY: Yes, availability of raw materials. What could go wrong? What could go wrong in a nuclear powered automobile?

AUDIENCE: Two cars crash into each other.

BLADE KOTELLY: Two cars crash. That doesn't seems so wrong. So far, it sounds OK. Or are we talking about fusion? What do you mean by that?

AUDIENCE: Finding out what happens--

BLADE KOTELLY: Oh, what happens to the nuclear reactor during a car crash. What was that movie--was it the new Batman?

[INTERPOSING VOICES]

They had a nuclear thing in a truck and it kind of like, boom, boom, boom, boom. You're like, oh no, that seems so bad. But everything worked out just fine. Batman saved the day. OK. What else?

AUDIENCE: Can it be modified to serve another purpose.

BLADE KOTELLY: Such as? A what?

AUDIENCE: Like a more dangerous purpose.

BLADE KOTELLY: A more dangerous purpose. So yes. You could have terrorists who take advantage of the fact that you have a nuclear powered car to create a nuclear powered bomb. I saw that in "Batman." I know. I saw. Everything I ever needed to learn, I learned from watching "Batman." Cameron.

AUDIENCE: If it's a fission reactor, where does the waste go?

BLADE KOTELLY: Ah, waste. Yeah, what do you do with waste disposal? Right. Ben.

AUDIENCE: Exposure to radiation.

BLADE KOTELLY: Exposure to radiation. Yes, absolutely. Charlotte.

AUDIENCE: Control and proliferation concerns.

BLADE KOTELLY: Control and proliferation concerns. What does that mean?

AUDIENCE: If you create nuclear waste, and you can't control it, someone can take it and turn it into a nuclear bomb.

BLADE KOTELLY: Yes, OK. So how do we keep that thing from happening that could be used negatively and prevent that. What else could go wrong?

AUDIENCE: Do it yourself people.

BLADE KOTELLY: DIY. How to build a nuclear reactor at home. Yes this may require a few more tools than most people have. OK. So are you beginning to see how we can start applying this process to things of engineering base as well? Right, that you have to make?

And now, you may not be making a nuclear powered reactor car right now, but Charlotte, you're working on these small reactors, right? And what could they be used for?

AUDIENCE: So the market shares that number one, reactors are really expensive and they're very big. And if you don't need 1,200 megawatts of power and you don't want to spend $7 million, you can get 250 megawatts of power for $1 million.

BLADE KOTELLY: OK. So you could make a small reactor and use it to do what?

AUDIENCE: Basically, you create electricity and then distribute it cheaply.

BLADE KOTELLY: So cheap electricity. And where would you want to do that?

AUDIENCE: All over the world.

BLADE KOTELLY: All over the world. In even a company, potentially like Apple where they have that new campus being put up. They have their own power energy place and they might, potentially, put a nuclear reactor there, right? They could power their whole thing and then supply the energy back to the grid, if they chose to do that. OK. Joel, did you have a--?

JOEL SCHINDALL: Yeah. This process we're going to use again and again during the course of the term. But I wanted to just point out a few things to set a little bit of context for you.

First of all, I think there's an image that designers just kind of go into this special sort of a daze and they come out with a wonderful invention, a great dress, a beautiful room layout or something like that. And I want to point out that it rarely happens that way.

The design is work and effort and looking at relationships and going again and again. And looking at what's wanted and what's needed and what's the context of it. And actually what we described here is not that different from what you do as engineers when you study engineering. It's breaking down the problem into parts, looking at the relationship between those parts, and optimizing the system, just like you optimize an engineering system that's designed to generate electricity or build a bridge whatever branch of engineering that you might be involved in. So actually you've got the kind of training to be able to do good design.

Second point I want to make-- the numbers, one, two, three, four, five. We all know how to count. So it sort of leads you into thinking you do one and then you do two and then you do three and then you do four. And again, not that way if you recognize that. Actually, good design, you're actually doing it in parallel.

You get about up to number five and you're doing the hazard analysis, you realize some of the things, the assumptions you made early ain't going to work that way because they're dangerous to your health or other people's health. You go back to step one. So actually, this is a very good linear way of representing it. But in the actual implementation of doing it, you're going to move in and out of all those different phases.

And then the third thing I want to say doesn't quite apply here but I spent a lot of time in the satellite industry. And in the satellite industry, you go through a very careful analysis up front of the design that you've come up with. Make sure that it's reliable, that everything's going to hang together. And then, later on, down around here, you wind up making a few changes.

Things are just a little bit different. You modify this. You modify that. And almost every serious failure that occurs is because after you made those changes, no one

kind of went back to the beginning and said, well did this perhaps change the assumptions under which we based our design and move us onto a different track? So again, you always have to be aware of those things-- just kind of a perspective to put on it.

BLADE KOTELLY: Rita.

AUDIENCE: So say I'm Course 20 and I was hired by a Course 22 company to be a project manager and I don't even know of the existence of some of these problems that could come up. How do you go about figuring that out?

BLADE KOTELLY: Ah, yes. How do you solve a problem when you don't know much about problem space. That is a good question which we're going to hold for now because of time. But we will address it because you will all be working on problems over the semester which you may no knowledge about. And so the question is how do you acquire that knowledge and how do you figure out what you don't know. It's a great question.

I want to talk briefly about innovation. This is a huge thing. The course called "Engineering Innovation and Design." I have a very particular thought about innovation that I want to share with you. This is a diagram from a very famous design consultant and how they explain innovation.

Now, I think I see where they're going. They talk about the business on one side, technology and people. And they say, look, innovation happens in different places here. Process innovation occurs between business and technology. Functional innovation occurs over here. Emotional innovation occurs over here, like building a brand. And then they have experience innovation. And this is this thing that's very, very special.

They say yes, when we combine understanding of the business, the technology, the people. Do we build something that people want? Is it able to be built? And will it create a business that can sustain itself? Then we have achieved great experience innovation.

Now it's not a bad model. And it's not untrue that innovation occurs in these places. But I think it's not a useful model. I think in that zone here, you build things that are useful. They're useful. But they may not be innovative. So here's my thing about innovation.

There's something out there. There's something. And you're required to do something and yet you have this other tension pulling you because you desire to do something else that seems in conflict. I'm required to create a nuclear powered car but-- I desire to create a nuclear powered car, but I'm required to adhere to laws of government, which is causing a lot of problems.

I am required to make an artificial heart valve and I want to make that but what I realize is that there's a problem because in this requirement, I have something that spins and it creates friction. And the friction causes blood platelets to form and causes clotting. And I desire to have no clotting happen even though I have this spinning object in a heart valve. Tension.

I'm required to pass the class but I desire to go out drinking with my friends. These are in tension. OK. So when you have this and you start stretching this, by resolving this, this is where innovation occurs. Innovation is the result of resolving your need to do something with your desire of how it can be done. The designer's job is to reconcile the seemingly irreconcilable. The designer's job is to reconcile the seemingly irreconcilable.

It's not that you can't do it. Maybe you think you can't do it. It appears that you can't do it. But you gotta think about it differently or think about it from a new angle. Or get some new information to resolve the seemingly irreconcilable. And that is what your job is your whole lives is to try to figure out the solution to these problems.

If they were obvious, people would just do them. But when they're not obvious, and they cause this tension, this pain, this is where the innovation occurs. And where you get people who do things. Like a company called Levatronix who took that spinning thing. And they said, well, we know if they're touching it causes friction. Instead, they used magnets to levitate it so there's no friction at all inside of a heart

valve. Do you want to talk about the heart valve for a second?

JOEL SCHINDALL: There's a small company out in Walton called Levatronics. And part of their charter was to build an artificial heart that could be used at least temporarily as substitution until a real heart was available for transplant. And you know, the usual way that you build a pump is a rotary pump that produces just a constant pressure. But everyone knows that the heart beats like this. And everyone assumed that the body needs that heart beat in order for the biological processes to work as they're supposed to. Turns out, that's not the case.

Turns out that if you pump blood smoothly through the body, it works. You get oxygen from the lungs to the parts that need it. And you actually can have a working rotary heart pump. So Levatronix thought, well, this would be a great thing to build except that the spinning pump shaft has a bearing at either end of the shaft and there's friction in the bearing which creates heat, the heat creates blood clots, the blood clots break off and go to the lungs and that's an embolism and the person dies.

So the question was, well, looks like you can't do it. So talk about reconciling the seemingly irreconcilable. It turns out that you can magnetically levitate the ends of the shaft so that they don't actually touch the bearing. And you have a frictionless bearing. Now, it's not stable. It takes an external electronic circuit in order to be able to sense the little latitudinal motions that come up in the shaft.

But we're pretty advanced in our technology now. We can sense the position of the shaft and you can fix that. And Levatronix has actually been selling that product for the last four or five years. It's saved lives. It works. It reconciles the seemingly inconceivable-- well, inconceivable-- but irreconcilable. And that is what I would call a real out of the box innovative idea. Yeah.

AUDIENCE: Is this the company that they were written about in "Popular Science?" They were having people who had these smooth hearts going in. And they were going into doctors and freaking the doctors out because they didn't have a pulse?

JOEL SCHINDALL: It certainly would fit. There were a few articles about Levatronix. I don't know that specific one. But yeah, that's right, they don't have a pulse. So when you say that to be alive, they must have a pulse, perhaps that's not a necessary precondition.

BLADE KOTELLY: OK. So I want you all to work in pairs for just a few minutes. I want you to come up a list-- let's see who can come up with the longest list in three minutes, what group can come up with the longest list in three minutes, of either things you've experienced personally or things that you know about where people had to reconcile the seemingly irreconcilable. To solve a seemingly impossible design problem at the time. You have three minutes.

All right, let's find out. OK. Who put down one thing or more? Wow. Pretty good. Two. Three things. Four things. Five. Six. Seven. Eight. Nine. 10. OK. 15. 20. 25. OK. 21. 22. How many did you get?

AUDIENCE: 22.

BLADE KOTELLY: 22 things. 22. Both 22?

AUDIENCE: 21.

BLADE KOTELLY: 21, OK. Who only got five or fewer? Five or fewer. Tell us one of them.

AUDIENCE: Portable media players

BLADE KOTELLY: Portable media players. Tell me what you mean by that.

AUDIENCE: [INAUDIBLE]

BLADE KOTELLY: Yeah, go ahead.

AUDIENCE: Basically making something that is small and functional.

BLADE KOTELLY: That would do what?

AUDIENCE: Playing any kind of media.

BLADE KOTELLY: Right. OK. So it's like the idea of putting all your music in your pocket, right? That

seems impossible to do at some point in time, right? And now you're like, of course, all my music's in my pocket, all my videos are in my pocket, everything's in my pocket. Got big pockets. OK, yes. So things like that. That's an excellent one. In the back, yes.

AUDIENCE: Infrared thermometers. Infrared thermometers.

BLADE KOTELLY: Infrared thermometers. Yeah. How to be able to get the temperature of something at distance. Well, you got 21 of them. We're going to work our way up to you. OK people who got 10 or fewer. Groups that got 10 or fewer. OK. Tell us, Daniel.

AUDIENCE: Selling a product without a salesforce.

BLADE KOTELLY: Selling a product without having a salesforce. Right, that's an amazing idea. Like, what do you do when you don't have anybody doing the selling? How can you possibly do that? And said, ah, I've got the internet. I'm Jeff Bezos. I can sell everything the world.

AUDIENCE: A self-driving car.

BLADE KOTELLY: A self-driving car. Yeah. It seems impossible. GM is working on this and putting a lot of effort into this. In fact I've had a conversation recently with someone who thought there's no way we're going to have self-driving cars in the next 15 years. They think well, maybe for special lanes, special places. But I think we're going to see a lot more self-driving cars with breathalyzers on them. [PUFF] You are not driving home. Get in the backseat. You pass out. You wake up at home. OK. Amazing! Who else? 10 or fewer, yes.

AUDIENCE: Oh, no sorry, I had more.

BLADE KOTELLY: You had more than 10. OK. Who had 10 or fewer?

AUDIENCE: Nuclear fusion.

BLADE KOTELLY: Nuclear fusion. Can we do it?

AUDIENCE: Yeah, just can't sustain it.

BLADE KOTELLY: Just can't sustain it. Interesting. So we're so close. But we desire it. What else? How about 15 or fewer. I'm sorry, were we at 15? 15 or fewer.

AUDIENCE: The invention of the light bulb.

BLADE KOTELLY: The invention of the light bulb. So people thought, boy, how do we get light without candles? Right. How can I stay in light without candles? Who invented the light bulb?

AUDIENCE: Not Thomas Edison.

BLADE KOTELLY: Not Thomas Edison. That was a correct answer. Swan did. Swan did in England. Smaller version. Swan invents the light bulb. Edison's like, ugh, you. And he spends a lot of time trying to figure out how to get around this patent. But we all call them Edison bulbs and not Swan bulbs. Do you know why?

AUDIENCE: Because he made them really big.

BLADE KOTELLY: Because he made them really big. How did he do it? So clever. So in this whole thing, we talked about process, we talked about stakeholders and all these different people who are involved. And Thomas Edison had a very smart staff. And the staff had a very big-- we call it systems thinking perspective.

They said, well look, candles are used or things that supply light and heat, gas lamps, are used on the side of fireplaces in a very expensive homes. Particularly in Boston. They said, here's an idea. We're going to take these light bulbs things, we're going to run wires right through the tubes that currently kept gas, we'll turn the gas off, and we'll put a little meter outside of your house that will measure how much of this electricity you're using for your light bulb. It's all brand new, right? So everyone's like, whatever, OK. And so they did it. It's cool because it won't burn down your house.

And they put these bulbs in and they ran the wires through. Because they, said, if you don't like it, we'll pull out the wires, turn the gas on, everything just works. So it's

easy low switching costs. Easy to start trying it out. Low risk. If you don't like it, you can go back. No problem. Money back guarantee. And a way of measuring it. And that's why he became hugely successful.

OK. Great. Other inventions from people who got 20 or fewer.

AUDIENCE: Yeah. SR-81 Blackbird.

BLADE KOTELLY: Yes. The SR-71 Blackbird. Yes. Something that would go incredibly fast. How fast does it go? So fast we don't even know! I think it's still classified. And it goes so fast and flew so high that it couldn't be caught on radar. You couldn't even see. You didn't know it existed at the time.

AUDIENCE: The design compromise was about the fuel because it's not sealed at ground level.

BLADE KOTELLY: Ah, yes, so the design compromise specifically here, is that at ground level, it just leaks fuel. Because when it goes so fast, it gets really hot. And we all know from your thermal class that things expand when they get really hot, like metal.

And it would expand and all of a sudden not leak fuel when it was flying really fast. But on the ground it is just dripping fuel. Pretty crazy, right? What if your car ran like that? I'd love that. I could drive fast all the time. I'm sorry, Mr. Policeman. I had to drive fast. I'd be leaking fuel all over the ground.

AUDIENCE: Alternating currents

BLADE KOTELLY: Alternating currents. Tell us. What was the--

AUDIENCE: They were looking for a way to distribute and transmit high voltage. Enough electricity to keep the [INAUDIBLE] and direct current would break. Would not-- it wasn't--

BLADE KOTELLY: Didn't work. OK.

AUDIENCE: Motion pictures or movies.

BLADE KOTELLY: Movies. Yeah. Movies. I want to see in front of me, stuff happening like I'm there.

How do I do that? I just have to put you there, in front of a train, speeding towards you at 100 miles an hour.

Or put a camera and I project on a big thing. And it's so big, it's so exciting, that people in the audience were aghast. They gasped when they saw people moving. What else? Actually, coming off of that-- color. We don't think about color too much. All we think of is black and white. But we want it in color. And that was a huge process change.

And how about 22 items or fewer. We'll give you a chance. Go ahead, Patrick.

AUDIENCE: The printing press was a big one.

BLADE KOTELLY: The printing press. Yeah, huge deal. What was the issue?

AUDIENCE: They were having to have scribes--

BLADE KOTELLY: Yeah, you have to copy everything by hand which leads to lots of--

AUDIENCE: Carpal tunnel.

BLADE KOTELLY: I don't know if they really cared about the carpal tunnel syndrome thing back then. They might have cared. But lots of errors. Lots of errors and translation errors and tons of errors. And what else was the issue there?

AUDIENCE: Slow.

BLADE KOTELLY: Slow. It's very limited. So if you had a book, it's a very big deal to have a book. And probably in the future it will be a big deal to have a book again because we'll all be reading PDFs. And from-- is this your group who go 22? Yes. OK, yes.

AUDIENCE: Paper cups.

BLADE KOTELLY: Paper cups.

AUDIENCE: How do you use something that isn't waterproof to actually hold water?

BLADE KOTELLY: Right. So paper will let water go through it at some point when it saturates. And The question is how do you make it waterproof. Right. So these are all incredible innovations that occurred from paper cups to something like SR-71 Blackbird. And what I want to do is show you, quickly, a short video. This is a really interesting thing because the year it was made was?

JOHN: 1987.

BLADE KOTELLY: 1987. Take a look at this. OK, So I won't show you the whole thing here. If you'd like, we can send you a link. This is something Apple made in when?

JOHN: 1987.

BLADE KOTELLY: And in it you'll see there's a date that actually occurs. And the date is?

JOHN: One year before Siri is launched.

BLADE KOTELLY: Yeah. OK. So it's right around Siri's launch. And now we can do almost all the things you see in this video. You'll see there's a camera up there. He has a video chat with her. They're looking up things. He's correcting his spoken spelling of something which Google does all the time. With enough context, they correct things, sometimes even accurately.

He's getting his information here. He's reading appointments. This is all something that's happening now. This was the idea they wanted so desperately to create. Something that allowed you to do something in the most natural way, but with technology. And we're basically there. So for your homework, I want you to do something that maybe none of you have ever done before, your homework. No, the--

OK. I want you to design a game. I want you to make a game. There's not many requirements you have. But it's a two player game. Maximum cost of materials must be under $5.00. You can find materials. You don't need to spend any money.

But the cost of materials if someone were to buy them and make your game, has to be under $5.00. It must include an element of chance. Must somehow contain

chance by whatever method you want. And must be able to be taught to someone else within three minutes.

AUDIENCE: Do we actually have to make it or just design it?

BLADE KOTELLY: You need to design it and make it. You design it and make it. I suggest you even try it out. We might try some of them in class. We might try some of them in class.

AUDIENCE: This is due what day?

BLADE KOTELLY: I don't know. It's on your syllabus. I think it's due on--

JOHN: Next Monday.

BLADE KOTELLY: Next Monday. It's due next Monday. Yes, I'm not going to give you two days to design a game. OK. Thank you very much, everyone.