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TAFT BROOME: Let's do the news article first. Hot dog. My wife was very kind to Xerox right from the newspaper and then do some Photoshop edit to get a clean copy of this article. And this might be the best one to scan in and keep it on your computer, such as it is. But it has those three pictures in there. And it has it laid out just like it really is.

Let's talk about it. Give me a synopsis of it, and give me your thoughts about it. And when you give me your thoughts about it, tell me how you think it relates to this class and anything else you want to say about it.

AUDIENCE: It's hard to present a synopsis, but for me reading it, frankly, I was pretty horrified by reading this article. I mean, just oh, absolutely. Maybe because I'm new to engineering. I have a background in physics, which you talk about as kind of insulated from the criticism. And it really horrified me that that's what engineering is about.

TAFT BROOME: That was my learned judgment. Not everybody agreed, but yeah.

AUDIENCE: What do you think he said, this is what engineering is about?

TAFT BROOME: What in particular?

AUDIENCE: Let me see if I can find a quote.

TAFT BROOME: Yeah. How did-- well, you didn't have the pictures, but at least I think I showed them to you at one time.

AUDIENCE: You did. You showed them to us, and now we have them.

AUDIENCE: Is it the notion that engineers believe that nothing can ever be risk free? Is that what what you mean?

AUDIENCE: Yeah. Like, that was a little disturbing also, just the acceptance of--

TAFT BROOME: The nature of the lethality of it all.

AUDIENCE: And again, I think it's probably accurate. And I think there's probably nothing that can be done. But, I don't know.

TAFT BROOME: Well, I think that even when I wrote that article, I don't think that there was an engineer living who thought that engineering was risk free.

AUDIENCE: No.

TAFT BROOME: Now, they were divided as to whether they were going to tell it to everybody.

AUDIENCE: Right.

TAFT BROOME: And they were happy that a lot of people thought that it should be risk free, that it wasn't built into the system to be risk free at that time. People are wiser about that now. Take a few moments before I start commenting. Try to find your quote. Give me some more feedback on what you think of this thing.

AUDIENCE: Well, here's one. Some engineers now espouse a morality that explicitly rejects the notion that they have as their prime responsibility for the maintenance of public safety.

TAFT BROOME: Yes.

AUDIENCE: So again, I think it's true, but again, it's disturbing, you know?

AUDIENCE: Well, yeah. So he takes that stance. And I mean, you don't take that stance. You present that claim and then say, and here's what they do take as the primary. Here are three of their options. So I read this article. After I read it the first time, the second time, I read it to try to make concise statements for the four possible moral codes that you suggest for engineering.

And I want to make sure I got them right. So the first one is public safety is of the utmost importance. And that's how we decide on engineering morality. And then the second one I think you suggested that some engineers do is to say that decisions should always be made with personal judgment. And you should balance commercial interests of the client, of the public, and of our company. And if we use common sense, it will come out OK. So that seemed to be option number two.

TAFT BROOME: Keep going.

AUDIENCE: And then, option number three seemed to be what you called the contractarian code. And so this is to base decisions on only the entity with whom you have like a legal contract or business contract. So there's not actually this notion of having a contract with the public for their safety doesn't exist, because it's not official. It's not legal. And so the engineer who was in charge of that would say I just have to worry about the actual contract.

And then the last one you suggest is this ethic of informed consent, that we base our actions-- we take action to inform the public of the risk that we're taking in engineering, because we define engineering as experiments with human subjects. And we have a responsibility to let humans know that it's not just applied science, that we're using our intuition. But it was interesting, the way you talk about intuition.

So that seemed to be the fourth one. And I thought maybe that was the one that you would support the most, because you presented it last.

TAFT BROOME: OK. Let me tell you what got lost in the editorial. The original title for this paper-- well, let me give you the background. Let me give you the background. The editor of this piece, and I think that his name was Joel Garreau. My memory on that is 99%, because who it was.

Joel Garreau called me and said that he had called the public relations office at all of the universities in the area, and said that he was starting a new section, a new idea in the *Washington Post* that he called Outposts. And what he wanted to do was to get some issues that scholars thought were issues and bring them down. And I say down, I don't really mean down in the sense of a lower level of intellectuality, but a different kind of language, plain language. A plain language explanation of what the scholars are talking about, what they are debating.

Everybody else is talking about something, what are the scholars talking about? That was his point for this thing. And so, the person who was head of the public relations office gave him my name, and we discussed. I said, well, I got three pieces-- no, four pieces I think I had at the time, on my desk that were in various stages of completion that we could discuss. And he said on this one, the original title was "Cicero is Dead. Long Live Technology."

And I started the paper off with a quote from Cicero. Y'all know Cicero. He was a great Roman orator and lawyer. Cicero said, the safety of the public shall be the highest law. And I wanted to argue that the safety of the public was not the highest law in engineering, no matter what anybody in 1986 thought it was.

So I gave him-- and it took about a month to finish the paper, I figured. And I gave him over a document that was 30 pages long. And he broke it down to enough to fill this up. But it took up a whole lot of pages, you know? And what motivated me to write that paper was that I was cheering, and had been cheering for a couple of years, a committee with the Ethics Committee of the organization we talked about before, the AAES, the American Association of Engineering Society.

And we wanted to get this ethics code for the whole of the profession, civil engineers, mechanical engineering, I'm talking about the professional societies now. This was an organization of the professional societies. So I had just completed formal training and had gotten my degree, formal training in engineering ethics from RPI, had gotten my degree officially in '85.

And I'm sitting there with these engineers, and we are debating that particular issue. And what happened in the debate was exactly what happens in a philosophy class. The philosopher will put an issue on the floor, and then ask you well, what would Plato say about this? What would Aristotle say about this? What would Kant say about it? And going around.

And maybe they'll get, at the end of the class, what you will say about it. But they want you to know what all-- in my experience with engineering ethics, where all but two of my professors were philosophers. Because we were just starting the field, so nobody had a degree in it. And so the people who were starting the field did not have a degree. They were almost all philosophers.

75% to 85% of my classes would take that very formally. Put the issue on the table, and ask what the various philosophers would say, if they were sitting here, about it. I'm sitting in this meeting, chairing this meeting with these engineers, all of whom said that they had never taken a formal class in ethics before. And what they said in there could be categorized just like the philosophy class. Somebody said what Aristotle would say. Somebody said what Plato would say.

Now don't get me wrong. They were not entirely astute about what they were saying. The point is that it was just natural for them to come out with these different points of view. Somebody would say there's a principle involved. Somebody would say it's the consequences that matter. None of them had studied Kant. None of them had studied Mill.

So I said, well, this is a gold mine. So I wrote it up. Those points there were the points that came out of that meeting. And each engineer was in a position to speak responsibly, that is, for his-- it was all men-- organization, and for his and all involved experience.

So when I said that most engineers think, or that some engineers think, that was a credible interview with people who said that-- and it corresponded with my experience-- that that's what they think about these things. OK. So actually, those four points are made from that motivation that these engineers had actually just followed the book without having read the book, and without really doing it in a very defensible way. But it's natural. And if you walk into a class of fifth graders and say, is it right to kill? Somebody is going to say no, because that hurts their feelings. And somebody is going to say no, because it's wrong yo kill. It's just natural.

So Plato and Aristotle were not coming out of some abstraction with their views there, but it took a lot of work to get it in a defensible form. So that's what motivated those four points right. And so what I was coming out on those four points with was that all of them rested on the premise that the safety of the public comes first, except for one of them. That's the one where the person said you have to weigh these things into a balance.

And so what I argued, either there or in definitely in the meeting with him-- and I used the word argue not to be confused with the word quarrel. I argued with him-- and he never gave an answer-- that when you say that you have to weigh these things out and get a balance, then my question is, what rule establishes the balance? And his answer was you just know a balance when you see it.

And there is a legitimate kind of ethics called intuitive ethics. It's not popular anymore, but it's a legitimate form of ethics. And that is that people just know the right and wrong when they feel it. Now, it all goes back to something we're going to discuss a lot more later when we get into the narrative approach, and that's Plato's ethics.

And Plato was interested not so much in what we're doing, and that is a reasoned approach to an ethical problem. Plato said mostly that there is such a thing as a virtuous person. So he's talking about character. And a virtuous person would just know the right thing to do. So there's your intuition.

What did he count as the virtues? Well, there were Greek virtues, heroism and all of that, which means that they won't be the same as what you would require as virtues. But the important thing is that he spoke from the standpoint of an entire culture. He could write down half a dozen virtues and everybody would say, yes. This is what we think is a good person. This is what I want my sons and daughters to be like.

All right. So that's what that was about. What about some of the other stuff that's in there?

AUDIENCE: OK, can I just-- again, I won't let this down.

TAFT BROOME: That's good.

AUDIENCE: Is it common to think of engineering as an experiment done on humans?

TAFT BROOME: Now, let me tell you about that.

AUDIENCE: Maybe I was the only one slightly perturbed by that statement.

TAFT BROOME: All right. I'm going to give you a name. I'm going to have to spell it. I'm going to give you two names. The first name is Mike Martin, and the second name is Roland Schinzinger.

AUDIENCE: And they're mentioned in the article.

TAFT BROOME: His name is in the article?

AUDIENCE: Their names. Yeah, right where you said.

TAFT BROOME: Right where I said--

AUDIENCE: [INAUDIBLE]

TAFT BROOME: And they have a book entitled *Engineering Ethics.* And they wrote their book, I think before '86. '83. Roland became an assistant Dean of Engineering at University of California at, starts with an N. Well, he was an assistant Dean at the University of California-- no, it starts with an O. Anyway, and he invited me out to his house one day for dinner. I was in California. And so I drove down and he and his wife and I stayed up half the night talking about this, that, and the other, life.

Roland, one of Roland's parents is German, and he grew up in Japan. And his father was a diplomat in Japan. And so, Roland's views on the world can be very unique. And so when he stood up one day in a conference and said engineering is an experiment with the public as its human subjects, the whole place exploded, I mean, in a positive way. I mean, the guy just opened up doors, whatever. I mean, that was just a different way of thinking about the whole thing.

And for a time, many of us thought that that was going to be the basis for a philosophy of engineering, that that's what really what made the difference between engineering and science. It never worked out, but it was a very interesting way of thinking about the thing.

AUDIENCE: Why did it not work out?

TAFT BROOME: I don't know.

AUDIENCE: Maybe it was unsettling for people to think that they're just part of this experiment, and thinking if would catch on with mainstream, with everyday people, they wouldn't be too happy about that.

TAFT BROOME: Well, if that was the case, then we can hope that maybe 20 years from now after-- are you're familiar with the term the dust settles? After all of the politics tends to be no longer emotionally inspiring, that maybe that idea will come back. Ideas do come back. But it was definitely out of favor at the time.

AUDIENCE: And again, it's not so much that I disagree with-- I mean, I frankly think it's pretty ingenious way to picture what engineers do. So I'm not saying I disagree with it. But it was kind of disturbing to start to think about it in that sense.

TAFT BROOME: Oh, people were very hostile. When I say people, the academicians were not hostile to it, but the practitioners were. And the practitioners I'm talking about are not your everyday engineer with the hard hat going out, giving directions on how to build something. I'm talking about the vice presidents for each, and high level management. And some government, not all of them, they were very hostile to this.

AUDIENCE: Did they see engineering as experimental? Or did they disagree with the idea of letting people know that?

TAFT BROOME: Yes. They disagreed with letting people know that. But the book that I have recommended somewhere in this class by Henry Petroski called *To Engineer Is Human,* takes the position that engineering advances by way of its failures. Now, for some reason or another, now that book, I don't think referenced Schinzinger at all. But that's just another way of thinking about Schinzinger's position. Right.

AUDIENCE: It's a nicer way of saying it.

TAFT BROOME: And his idea was completely digested by the management and politically motivated engineers in the United States. They ate his book up. They ate it up. So it depends on this-- well, there's a formal term, I understand, in print media called the spin. Petroski put a different spin on it. And I'm going to make that case myself. I'm going to make that case in my book that Schinzinger's theory did not die. It came out in another form with another language. And it was completely absorbed positively by the engineering community.

So that is a lesson that you can take to a class in literature, that you can make something-- an idea-- digestible or not depending how you put the spin on it. What they used to do in the olden days was-- one of the things that I am very much interested in is a book by-- ever read this book called *The Nature of the Universe* by Lucretius?

AUDIENCE: Never read it.

TAFT BROOME: OK. It's a book that pretty easy to read. And if you get it and set it on your shelf one day, on Sunday afternoon, you'll have nothing else to do. And you'll read through that book. And this is fourth or fifth century BC. And he says that the universe is made of atoms. And between the atoms, there is a void. And the atoms move.

And he says all of these things in that time. I'll give a talk on that if you're interested, but the bottom line for what you just brought up is that-- or, what we're talking about when it comes to spin is Lucretius tried to make his ideas known. And people were yawning, and they were not interested. So he went back and wrote the whole thing over, ripped the whole thing up, inverses the point.

And he makes this metaphor. He says that physicians sometimes had the problem of getting some bitter medicine down his throat of a child. So what they would do with children is put the medicine in a cup and put some honey around the lip of the cup. And then say, oh. Don't you want this honey? And the kids will lick on that and they'd love it. They'd start drinking it. By the time they realize what they were drinking, they got enough of it down to do some good.

So he said for that, his poetry was the honey on the lip of his manuscript. So yes. If we learn, we're here. We can all learn a whole lot about the power of a spin on a story. Petroski's spin is the same thing, which is the basic idea.

What do you think this word slippery had to do with the title? That was an irritating word. Oh, keep talking.

AUDIENCE: One way I interpreted that word is to say that once you decide that the safety of the public is not the standard on which you base engineering, then the line can be drawn in [INAUDIBLE].

TAFT BROOME: Exactly. Slippery refers to slippery slope. And slippery slope, there are two formal terms in engineering ethics that mean the same thing. One is slippery slope, and the other is the domino effect. So those terms mean exactly what you think, that once you put a particular idea into a discussion, there will be ripple effects. And those effects are called domino effects, or that you're now on a slippery slope. You will wind up.

And what they usually philosophers were are engineering ethicists usually mean when they say this, is that when you put that idea into an argument, you will inevitably wind up someplace that you don't want to be. That's usually what they're talking about. So, OK. Oh, lastly, what do you think about this last page over here?

AUDIENCE: It definitely made me think about the advances that we take for granted that have been enabled by having this group of people that can say [INAUDIBLE]. I just hadn't thought before about the use of the military to create technological advances, instead of just using the military for defense things.

TAFT BROOME: Well, do you remember in the syllabus, there's a reference to Koen's book called *Discussion of the Method.* OK. Now, in that discussion of the method, Koen comes up with something what he calls heuristics. Now what he means by heuristics is that when you make an argument in engineering, you may come to a point where you want to say something and you can't prove it. Or, you may come to a point where you want to use some tradition and you don't want to justify it, just like we always do. These are his heuristics. And he's got a list of them.

And it would be nice if you got your hands on that book and just looked at a couple of the list of them. Some of them are mundane. Like for example, there's a heuristic about screws, that never make a screw that does not allow for 3/4 of a turn. You allow for a 1/4 of a turn, you're in bad shape. Now he doesn't want to justify that. He just wants to say that that's a good rule. Just seems to work out. Sometimes it fails, but it's a good rule to put here. Now here's what this is all about.

And it starts with the idea that what we call modern engineering, it evolved from the military. We're not talking about per se, the pyramids or the Great Wall of China. We're not talking about Leonardo da Vinci's inventions. We're talking about what happens when you start talking about engineering in a university setting, and you want to put it in a university because you want it to bring physics and math to bear on what you're doing.

The first engineering school in the western world was at Polytechnic Institute in Paris. And my dates may not be good, but it was early 19th century-- early, early, 19th century. Anybody know the first engineering school in the United States? West Point. And the first civilian engineering school in the United States? Rensselaer, 1824.

In the military, there are some characteristics about decision making that define engineering and make a distinction inside it. One of them is this, that the mission is more important than the people here. So, second is that your decisions are likely to be lethal to somebody. Thirdly, you don't have a whole lot of time to think the matter through.

All right. What we're talking about with those four principles there that we've discussed in the news article, "Slippery Ethics" are matters that apply to business, but they also apply to military. And they have all three of those characteristics in them. They have imperatives, that you've got to do something, that there is a willing to risk life. And notice what I'm talking about. The decision maker is risking the lives of somebody else.

And the third one is complexity, that you just don't have time, that the problem is just too complex to think through. There is a little quip that you can remember. The enemy's coming over the hill. What do I do? If you keep that in your mind, you'll understand a whole lot of sophisticated things about engineering.

You remember the picture of the School of Athens, and everybody's laying around in there, Plato and all of them? You're not in there. So, that's what motivates this idea of heuristics, that if you need a principle and you want that principle to be a scientific principle, you won't have time to get it.

So what principle do you use in its place? You need the heuristic. Now there's a beautiful metaphor in another discipline. And actually, it's a combination. It's called historical literature. And let's see. I can think of a good-- there is a good piece that I will put on the board for you. If you have any friends in literature, ask them about historical literature, but ask them about this.

And the book is entitled *Justinian,* and was written by a man named Turteltaub. Turteltaub is a historian, but his book is historical literature. But what he wants to talk about is a man who was emperor of Rome, who was deposed and disappeared for a time-- 10, 20 years-- and came back and got his emperorship back.

And what he wants to do is to talk mostly about what he did when he disappeared. And clearly, there's not a whole lot that had been written down about what he did, where he went, and what his life was like. One thing is for certain, is that he brought this lady back with him. And the two of them got his throne back.

Now, Turteltaub is able to discover a lot of people that Justinian encountered when he was away. And he found some facts. He knows the beginning and the end. But how do you make a story that ties together the beginning and the end, all right? Well, one of the things he-- and how do you make it readable for a public that's really not interested in all of these people this man met?

One of the things he does, which was done in the name of the roads, was that he would take three, or four, or five characters and conflate them all down into one character. That's a heuristic. Another thing is he might not know exactly what the man did, let's say if, he was in Antioch. But he knows the kinds. There it is. He knows the kinds of things that people had done. He knows what the atmosphere was like in Antioch. He knew what people were thinking about and what they were doing. And so what he would do is not ask what did he do, but what might he have done. That's a heuristic.

Engineering, I think, is very much like that-- that if you get an engineering document, you have to decide whether or not it's a branch of engineering science or not. Do you think that if you have a doubt, then look at the logic. And if you find somewhere in there that there's a heuristic that's used, then you've got an engineering document, not a scientific document. And I can be more specific about that, but that's where that discussion came up in this article.

AUDIENCE: So anywhere where you're relying on tradition, [INAUDIBLE] instead of [INAUDIBLE].

TAFT BROOME: And you'll find that in some of the most sophisticated engineering research papers. You'll find something in there that you can't justify entirely scientifically, but it looks mathematically rigorous. They are referencing to somebody, but when you're sitting down with engineers-- now you graduate students, you're going to have to do this. You're going to have to look down and ask yourself, what is the argument? What is the justification for every line in a paper?

And if you come to one that everybody says does not have a scientific or mathematical or a reason that can be justified-- let's put it this way, an argument that can be justified entirely on reason, then you ask, how can it be justified? Then, if you can find that it can be justified based on something else-- and I'll tell you what that something else is-- it's called rhetoric.

So there's a difference between a rhetorical argument and a discursive argument. A discursive argument is one that tries to get you to believe my point, the point that I'm making in the story based on reason and experience-- experience, meaning the facts. A rhetorical argument tries to get you to join with me in a great adventure, regardless of the facts-- or, better stated, regardless of the absence of the facts in my argument.

A good case of that is let's go to the moon. So when NASA says let's go to the moon-- or, better stated, when they said let's go to the moon, let's put a man on the moon, there were a lot of things we needed to in order to give the public a discursive argument that we can get to the moon. We didn't do that. Otherwise, we never would have left, because you get into-- there's another formal term a circular argument. You get into a circular argument.

I have to know something. The only way I could know it is to go there to find it out. But then, I've gone. I think we're in-- my watch says we got another 20 minutes. All right. So, that's the power of these heuristics. And Koen talks about those in detail.

And so, I think the best starting point for really understanding what engineers do when we decide that we're not going to be entirely scientific or discursive about what we do. And the importance in ethics to that is that in a participatory democracy, the decision maker has to understand that they're not being asked by these experts to believe what they're saying. They're not being asked to believe in the experts, they're ask to join with the experts in some kind of adventure, like going to the moon.

Beth, you're thinking very hard on that point. Want to share your thoughts?

AUDIENCE: Well, I'm just thinking the last few days about the expertise of the public, the trust the public puts in the expertise of the engineers, about whether or not that's a good thing. Yeah

TAFT BROOME: Yeah.

AUDIENCE: [INAUDIBLE]

TAFT BROOME: Well, another thing is that in this class-- not in all venues, but in this class, trust is not going to be given a lot of weight.

AUDIENCE: What do you mean? In an ethical argument? Or where would we find that?

TAFT BROOME: Do you want to jump in here?

AUDIENCE: [INAUDIBLE]

AUDIENCE: I think that's debatable. I think there's a segment of the public that's aware of risk and [INAUDIBLE], but Gail's comment, sort of that evidence that there's also people in the public that aren't aware of the risks, that sort of assume engineers are really smart and really educated, and arguing their way through things. I don't know, but you don't think that?

AUDIENCE: Well, I don't know. I was reading this article, they did mention stuff about people who [INAUDIBLE].

TAFT BROOME: Somebody said that?

AUDIENCE: Yeah.

AUDIENCE: In what article?

AUDIENCE: "Issues and Ethics, the [? FDA ?] and Government Regulations."

TAFT BROOME: Can you pass that around?

AUDIENCE: [INAUDIBLE]. do I trust-- like, he was talking about people who know how to regulate what drugs are good, and how to keep it away from the kids. They might say, we don't need a bottle cap. But there are people who, for whatever reason, don't know anything about being safe around drugs or whatever. So it's there for people who don't that type of necessarily capability. And those things come through regulations.

And he also said regulations come in different periods depending on how many tombstones.

TAFT BROOME: How many tombstones.

AUDIENCE: [INAUDIBLE].

TAFT BROOME: Well, I think that what trust-- the way I'm going to treat trust, and I emphasize the word I-- not necessarily you-- the way I'm going to treat trust is that when a person says trust me, the person is saying don't worry about believing what I say. Believe in me.

And no matter how decent a person you are, I don't want to believe in anybody. I want to believe what you say or disbelieve what you say or show. So therefore, I think that there was a time when people trusted the doctors. They'd get second opinions with lawyers, et cetera.

But today, I think that trust is not a big powerful word anymore, because I think it means what I just said it means. It means believing in as opposed to believe that. And nobody wants to do that anymore. That does not mean a person should not be trustworthy, worthy of trust, having good character. No. I mean a person should have good character. What it means is that a citizen should not have a relationship with an expert based on trust.

AUDIENCE: I think that's right. And what I was just thinking was that they might, or they do. And that's something we engineers need to be aware of.

TAFT BROOME: Right. And the reason that I didn't give that a lot of emphasis when you said it is because I remember when there was a time when people did trust experts, particularly engineers. And what we have changed away from is a great deal of trust to not necessarily skepticism, but some sort of equality where I want to make a distinction between specialist expertise and generalist expertise. They want to be an equal with the expert in what they call generalist expertise, going to that late. But that's the way that's the way we're talking.

OK. Are we done with this paper? Let's jump straight into the nuclear. I'll tell you what. Why don't we ask one of the students for credit to give us a synopsis of one of the cases, and ask the other one to do it the other one. Who wants to do Chernobyl, and who wants to do Three Mile Island, better known as TMI?

AUDIENCE: I have no preference.

TAFT BROOME: Well, then do the one that came first, TMI.

AUDIENCE: OK. Three Mile Island was an interesting accident, in that no one was hurt. [INAUDIBLE] some of the technicalities.

TAFT BROOME: Date? Place?

AUDIENCE: March 28, 1979. The plant experienced failure in the secondary nonnuclear part of the plant. And the feed water pump stopped running. There was some kind of mechanical/electrical failure which prevented the generators from removing the heat from the plant.

So, I guess first, the turbines shut down automatically. And the pressure in the primary system began to increase. And the relief valve opened. The valve should have closed when the pressure decreased by a certain amount, but it did not. And the signals that the operator was receiving didn't show that the valve was still open. And as a result, cooling water poured out of the valve and caused the core of the reactor to overheat.

AUDIENCE: [INAUDIBLE]?

TAFT BROOME: Yeah, well, I tell you what. Let me ask what I think is a real good question. What's the difference between the way a nuclear power plant operates and the way a nuclear bomb operates?

AUDIENCE: [INAUDIBLE].

TAFT BROOME: What's the difference between a bomb and a plant?

AUDIENCE: The purpose of it, for one thing.

TAFT BROOME: I want the mechanism. The bomb just explodes faster. I mean, it's--

AUDIENCE: It's the speed of the reaction.

TAFT BROOME: Yes. The other one is controlled, keeping the reaction down so that you can use the heat for other purposes. Yes, to run the turbines, to make the steam, to make the electricity. And et cetera.

AUDIENCE: So there were two things kind of going on. One interpretation is of the design of the plant was faulty, and the indicators and all were not up to par. They didn't work like they should have been. Another criticism has been that the-- I don't if they mentioned the guy who was on duty was not well trained, and so the staff at the plant was not adequate for what they were doing, and the damage that could have caused.

AUDIENCE: They did say that in one of the synopsis I read, that the people on duty had less training than they should have.

AUDIENCE: And at one point, they missed a signal that valves were closed.

AUDIENCE: Right.

TAFT BROOME: Now, that last complaint about being trained well enough, you'll find that complaint almost everywhere. Did you see the ethical issues in this particular case?

AUDIENCE: I didn't necessarily see any in the immediate response by the technicians to the alarms. But I felt like there, they were just acting on instinct. And there weren't that many ethics involved. They didn't know something was going wrong.

AUDIENCE: And it goes back to what you were saying about the time scale that most of them were on. When that happened and these things--

TAFT BROOME: Oh, that was time constraint.

AUDIENCE: Yes, kind of maybe too late at that point to say they reacted.

AUDIENCE: Yeah, but there were definitely ethical issues in the decisions that the authorities made about when to tell the next level of authority, and when to tell the public, and whether or not to evacuate. It was easiest for me to find ethical issues in those decisions. How much of a risk is a small amount of radiation that is leaked out to the people, versus how much of a risk is it to evacuate everyone, which is costly and could produce more accidents?

TAFT BROOME: So, actually, one way to look at it was that it was a safety-- an ethical issue plus a safety issue, because even when I wrote this article about safety not being the most important issue, I didn't say that it was not an issue. Safety is a big issue in engineering. And notice, what I'm saying about engineering is what I think engineering is, not necessarily what it should be.

So there was a safety issue. And the question had to do with notification of the public and evacuation of the area.

AUDIENCE: I have a question. [INAUDIBLE] about discovering new things [INAUDIBLE] I don't know if-- how much does-- I'm sure [INAUDIBLE] because of them, but when you put them in a group [INAUDIBLE]. That's why I think government-- I keep bringing up government regulations, but I think they're there to try to raise the way that an engineer would [INAUDIBLE] on safety. [INAUDIBLE] a lot of disasters happening all the time.

TAFT BROOME: An argument that I made once-- which really was not so much an argument as an experience-- was that when engineers and the so-called public disagree on the margins of safety, then what the engineers have done is to go back to a public forum and say, well, we could be more safe, but a glass of water will cost you $1. Then the public will start saying, well, start agreeing with the engineer.

So actually, what happens in real life is that the more the public is informed, the more the public tends to be like the engineers. They don't want to spend $1 for a glass of water. Now, what really-- and I'm going to get Professor Levinson in here who does safety to talk about safety. But there have been some psychological studies on safety. And people regard safety psychologically in a way that's not entirely rational.

One example that I know about-- and I'm talking about secondary sources for me. The sources are good scientific sources, but I'm talking about what I've read. You can read it too. It's not an argument that I'm making. The people tend to think that an airplane is less safe than a car. It isn't.

The probability of being injured or dying in an automobile accident is like three or four orders of magnitude greater than dying or be hurt in an airplane. Now, the conclusion that I've heard made-- and I have to buy it because I'm reading it, not trusting in but I do have some basis of trust for what scholars and experts say to each other in public when they debate it-- is that the mind regulates safety in very complex ways. And one way is controlled. You're not in control of the airplane. You're in control with the car. And so you think it's safer because you feel safer, because you have control.

But getting down to the public when it comes to business of safety, if you get it into an open forum where the engineers are there saying, I can give you what you want. Here's what you have to pay for it, there's a good likelihood that by the time the day is over, that everybody agrees to go back to square one. Yeah.

Let me give you some surrounding circumstances today, as we'll conclude this on Thursday. Then, I'm going to ask between Thursday and Tuesday, you all write something. We're going to do some more writing. Find out what this movie is about and when it was made, called *The China Syndrome.*

You all have to see it. You probably don't want to see it. But I think you need to see it. The important thing about *The China Syndrome* is-- well, there are two important reasons. The two reasons I gave you this as an assignment is just what I want you to know is the theme of this film and the date that it was made. And what I want you to do is to look at the theme and the date and compare it with the date and your analysis of TMI.

And on June 1, 1979, I went to work for the Nuclear Regulatory Commission. And they were still buzzing about it. Clearly, it wasn't about TMI. So I can give you some firsthand personal experience as well, what it was like when people were buzzing around with that. I went to work at the research office. It was in Washington, DC. And it was combined mechanical and civil engineering research office. And they had just started with an administrative experiment called summer research faculty fellows. And they said I was the first one, but it was an experiment.

But as an experiment, I got to walk around and see and talk a whole lot of people. And one of them, his last name is Costello. I'll never forget him, real decent guy. Had the equivalent of a cellphone on a beeper on his belt. And the idea-- it that was common knowledge that was the idea was-- and this is what I was told-- that when that beeper went off, somebody was calling from the White House.

So it was high security, and people were nervous on a daily, hour to hour basis. So I can give you some background on that. What does your textbook-- does your textbook say anything about the moral issues in that? Kind of vague.

AUDIENCE: Yeah, we had to go to other sources.

TAFT BROOME: OK. Try another source, see what they say about it. See if anybody has anything to say about the ethical issues. Then I have something to say about the ethical issues. Then we're going to do Chernobyl. Oh, I've got one other assignment before you get back, and then we'll call it a day. Anybody heard of this cartoon called *Speed Racer?*

AUDIENCE: I've heard of it, but never seen it.

TAFT BROOME: OK. There are two versions of it, the old version and the new version. *Speed Racer* is a cartoon made for children. The new version, I don't know what it does. New version came out in the '80s. The old version came out-- well, no. The new version came out in the middle 1990s. The old version came out right before this.

The theme was give child experience of what it's like to be in a non-Newtonian universe. So when *Speed Racer* got in his car and started driving down the street, the tops of the buildings would curve in at the top, which is exactly what's predicted if you approach the speed of light. And so, one of the arguments that I heard made was the real trouble with nuclear power in this country was that the engineers could not have an intuition for it. And so the public didn't trust what they had to say. They didn't think they really-- they thought they knew all that they knew was the calculations.