The eLearning Coach Podcast #32
ELC 032: Effective Learning Strategies
With Roddy Roediger
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Welcome to The eLearning Coach Podcast, online at theelearningcoach.com. I'm Connie Malamed bringing you ideas and tips for success with creating online and mobile learning experiences.

Hello, learning people, and welcome to episode 32. Are you fascinated by how people learn and are you eager to find out the most effective learning strategies? If that sounds like you, then I'm pretty sure you'll find this interview absorbing. Today I'm speaking with Roddy Roediger, PhD, who was a psychology researcher, distinguished professor, and Dean of Academic Planning at Washington University in St. Louis. He is one of the co-authors of *Make It Stick: The Science of Successful Learning*, which I highly recommend. His research has centered on human learning and memory, and he has published about 300 articles and chapters, mostly on various aspects cognitive processes involved in remembering. Here is the interview.

Connie: Good morning, Roddy, welcome to the eLearning Coach Podcast.

Roddy: Thank you, good to be here.

Connie: Today we're going to talk about learning, the myths of learning, and that's why I wanted to get a knowledgeable professor talking here. Can you tell me how cognitive psychologists define learning?

Roddy: The basic classic definition of learning is the improvement over time from experience in some skill or task. More colloquially, learning by cognitive psychology is pretty much what everybody means by learning, it just happens, like kids learn your language, they don't try to learn, they just do it. And so it's just the change in performance over time is the function of experience.

Connie: In your book *Make it Stick* you talk about several misconceptions that people have about learning. Can you explain two or three of the more common misconceptions?

Roddy: Sure. Let me use some examples from university education. I've worked in a university but the same seems to be true for high schoolers and middle schoolers. If you

ask students how they prepare for a test, what do you do to learn when you're going to take your test, the most common answer is that, well, I underline my text or highlight it, I go back and reread my highlighting or underlined passages, I do the same with my notes, and that's how I study for the test. Basically I reread and review the material. And that sounds perfectly reasonable, and it does get students through a test, but what evidence has shown is that things that are learned in this way tend to be forgotten relatively rapidly.

And so even though repeated rereading gives you this sense of familiarity with the text, and maybe you will know it for a day or two, which is of course what you need to get through the test, that's why students do that, but these kinds of techniques relative to others really impair long-term learning. Teachers always bemoan the fact that students have taken statistics and then they have to take another course later, and the teacher assumes they know statistics but discover that they don't. So the teacher has to go back and review some of the basic statistics stuff they thought they knew. So in high school and middle school teachers talk about how information evaporates over a summer. So you have to start reviewing again in late August what you left off with last May to bring the students back up to speed.

So one method of learning is that if I reread I will know it, and also students tend to believe that if I know it now I won't forget it. There have been studies asking students to predict their own forgetting, and they don't do a very good job of that. They tend to think I know it really well, I'll probably have it. So what can you do to counter that one myth? One thing we've suggested is, instead of just rereading, to make up questions and to test yourself, to use what we call retrieval practice.

So you read all these analyses of education where we speak of students gaining a storehouse of knowledge, and so the biggest problem is getting information into memory. And, sure, you need to do that, reading is good, you have to read, you have to listen, and you have to discuss to get information learned and into memory. But the other thing that we tend to forget is you also need to work on retrieving it, on getting it out when you need it, quizzing yourself. Making up questions and testing yourself improves learning more than rereading. Of course you have to give yourself feedback if you miss something. And many studies have shown that testing yourself is a much effective way of long-term learning than is simply rereading. And yet it is harder, and so students, even if you tell them, hey, this really works, sometimes it's hard to get them to do it just because testing yourself is hard.

Connie: Let me ask you something, a lot of the audience members develop training for the workplace, to me a corollary for that cramming seems to be 8-hour training sessions, 2 or 3 days in a row of 8-hour training sessions where the forgetting curve is great. Would you agree with that?

Roddy: Absolutely. Since the book *Make It Stick* came out, my co-authors and I have got a lot of emails, mostly from people in the training industry, training in the military, besides teachers, and even from football and hockey coaches and places like that. Because one way that training occurs, so there are these intense one-day seminars that are so popular because they seem efficient. But when I talk to sales people, for example, you've got many products you need to know the specifications of to go out and sell them. Well, if you're trained this way, it's going to be very hard to keep those straight, you'd be much better—I know it's much more difficult for the companies to pull this off, but it's much more effective if they have this spread out. And so some companies are developing online quizzes for their sales forces where you would ask them what is X product, and they would have to think about it and then they will get feedback. But one thing retrieval practice does is it lets you keep information at your mental fingertips, that if you keep practicing retrieval then you'll have the information when you need it.

One example I use and show my students, I had to learn the 50 states and their capitals when I was in high school. Well, I tested myself a while back and I only knew about half of them. So I just used retrieval practice just to show my students you can learn many things you want to know and keep them at your mental fingertips. If I just review those capitals every few weeks I'll have them for as long as I want to have them. If I stop doing that, they'll probably start, at least the harder ones for me, will start fading away. And so retrieval practice really is efficient for people in business, in the military, we've been talking to them. And the idea also of facing practice out, and interleafing practice on one thing with information on other things.

Connie: Yes, we'll talk about those strategies soon, but one thing I wanted to ask is, in a cognitive psychology model, why does retrieval practice work?

Roddy: We know it works. We don't have a deep theoretical understanding of why. There are a number of cognitive psychologists, including me, working on this problem. I can give you some general answers that are not too satisfying. But here's one. There is an idea of what is called 'transformer appropriate processing' in my field, and the basic idea is you want to learn in a way that will transfer to what your ultimate task is. So if a salesperson's, say, ultimate task is to walk into somebody's office and say I represent

all these different products, and the person being approached says, well, I'd like to know about this one specific one, well, you've got to be able to call that up. I have textbook sales people who come by my office—not as much as they used to because the market has changed—but I'm always impressed that they can just look me in the eye and say, oh, you teach so and so, here is the book we have, here is all about it, here's who the author is, as opposed to somebody who has this giant notebook with them and opens up the giant notebook and starts looking down and says, well, here's a page, and pulls out the page and hands it to me.

Obviously the first is much more effective as a sales tool. And how you do that? Well, you practice retrieval. So if you're practicing mentally walking into a person's office and they're saying this is what I know about, and then you need to tell them, well, if you just read the thing over and over you probably won't be able to do that, but if you practice retrieving it in front of your computer, you'll probably be able to retrieve it when you're in an office trying to sell it to someone.

The idea of transfer appropriate processing is what you eventually going to need to do with the knowledge you're requiring is to use it. So that means while you learn it, you should practice using it, you should bring it out and practice displaying the knowledge to yourself. And that way you will be able to do it later.

Connie: That makes sense.

Roddy: I mean, that's not a satisfying deep expiation, but that's kind of one that I use, because I think it does make sense to people that-- just like I tell people imagine ice skating, no athlete will ever think of learning something by watching great performances on TV. That might help you if you're really expert in the sport, you might pick up a few tips, but if you're a beginner, it's not going to do you any good, you would have to practice what you're trying to learn. And we think, well, that's different than education because that's the declarative knowledge not procedural knowledge like ice skating, but the same principles work.

If you are learning textbook material or your sales manual or your training manual in the military, you're going to need to use it, that's why you're learning it. And so you should practice using it as you learn, and that will make learning much more effective in the long run. You won't lose it as fast. You might still need to review it and to test yourself occasionally to keep practicing retrieval, but as long as you do that you can keep it for a very long time.

Connie: So what do you say to people who criticize testing because they think it doesn't promote higher order thinking skills. I know in the world of adult learning we really try to focus on the higher order thinking skills.

Roddy: Yes. It's a very good question, I get it often, and I have been criticized for saying that testing is good. So let me make a couple of very related points. One is that in order to apply any higher order thinking, so let's say I am a psychologist, so I have been studying psychology for my whole life, so I have a deep knowledge base, and what testing does is it permits you to have a deep knowledge base that can bring facts to you at your fingertips. So the only time you could really apply higher order thinking skills is within a particular domain. We don't find that there are domain general thinking skills. In other words, I might be able to be creative in psychology, but put me in Physics context where I know nothing, or high school and college physics but not anything approaching what you would need to know today, and I'm not creative, my high-order thinking skills don't apply. So with quizzing and testing what retrieval practice does is to help you build up a deep and wide knowledge base, to which then you can apply higher order thinking skills.

And, by the way, it's very hard to teach higher order thinking skills. I really don't think we know how to do it. So saying that testing doesn't necessarily do it, I would agree and I ask people, well, what would you do instead, and usually I'm met with silence or you should read books on higher order thinking skills and that kind of thing. But the finding in psychology is that creativity is domain-specific, you can't take a creative person who is an artist and expect them to go in psychology without huge numbers of years of training to apply the creativity, it is just the wrong way to think. It's like either we have higher order thinking skills or we don't. But, more accurately, we have them in some domains and we probably don't have them as well in other domains, because we don't have the knowledge base. To be creative you have to have a huge knowledge base.

So I think of the retrieval practice as helping us acquire the huge knowledge base to which one would then need to apply the higher order thinking skills. There have been some experiments, very interesting ones, comparing rereading to quizzing and then transferring people to different but related knowledge bases. So, for example, Andrew Butler who was a PhD student with me for dissertation, he had people read and reread passages on, say, sonar and submarines, and so they would learn that, and then they would either reread about it or they would be quizzed, they would answers questions about sonar and then be given feedback, whereas in the reread group they will just be given the feedback without being tested. And after that he showed the people the usual retrieval practice effect, the people who practiced with the retrieval practice, when you

test them later about sonar and submarines, they know more. So Andrew showed that. But he also then gave them tests later on to see if they could transfer their knowledge. So he gave them questions about bats and sonar. Same general principles in bats as it is in submarines, really you're sending out sound waves that are bouncing back to you, you're localizing things by the return of those waves. For the bats it's in air, for the submarines it's in water, but the same general principles. And what he found was that the people who had learned via retrieval practice showed greater transfer from one type of problem to the other type of problem than did people who simply reread. So they learned not only in their domain but to a related. This would be what I would call near transfer, because it wasn't like he had tested on something far, far away from those principles. But still it was some transfer.

The holy grail of education research is to show transfer, that what we teach our students, they'll not only know this, but they'll be able to apply it in some new situation. And so in my way of thinking, there's a lot of work going on about this right now, but practicing retrieval, again as I say having them at your mental fingertips, bringing them into mind readily, that should in my opinion transfer when you try to apply your knowledge to some completely new domain. But, as I say, there is lots of work going on this right now, the jury is still out, there are some positive results like Butler's, but there are some no results where people using retrieval practice haven't been able to show any more transfer than people rereading. So I think we just need a lot more evidence eon this point.

Connie: That's interesting. In terms of what people do to supposedly promote higher order thinking skills, I know in the world of workplace training what we do, and you can tell me if you think this is a good idea or could be effective, is that we present the learner with a variety of workplace scenarios. So we give them that basic foundation knowledge like you're speaking of, and then present many different types of scenarios to potentially use their higher order thinking skills to work through a problem. And if it's eLearning, we can take them down a specific path that has consequences. So if they make a choice then there's a consequence, and if they make another choice there's another consequence. So that if you were a doctor, perhaps your patient might die. You go down the entire path trying to solve a problem. What do you think about that approach?

Roddy: I think it's great. I think there's lots of evidence that if you're trying to learn a concept, let's in this case say a concept in surgery, we start off the book *Make It Stick,* Peter Brown, the lead author, had interviewed a neurosurgeon at the male clinic and he talked about how he developed new procedures applying his knowledge base. But is it

right? Yes, using multiple examples is typically a wonderful way. You can call it higher order thinking skills, but it's also just you have many more sources in memory to draw upon. And if you have been through all of these different scenarios, it's kind of like where you're trying to go down these pathways.

My daughter is a medical resident in New York and she sees different patients all the time and they have discussions, they have meetings about the patients, and all of the doctors will voice opines, and so I think that's a great way to learn from difficult cases. Someone comes in with a broken arm, they have a broken arm, okay that's pretty easy, but many cases obviously are very complex, and so I think a wonderful way of doing this is having a lot of smart people in the room talking about it, or, in your scenario, eLearning having many different cases that you try to apply. It's essentially trying to do the same thing via the internet that you would get from a case discussion, say, in a medical school context. So it's I think it's an excellent way.

Connie: Your talking about that discussion that they're having seems to be something that can also be simulated after a course having a forum where people will discuss cases.

Roddy: I think those are wonderful. People ask me, do students studying in groups, does that help? And I think if they can stay on task—the problem, I'm talking of students, is they wander off into other things—but if they ask each other questions, yes, I mean, that's essentially retrieval practice, and then you've got four or five people chipping in, here's what I know, here's what I think, and then of course if people get hopelessly confused you can always look it up in the book or something. But I think all of those are good ways to learn.

Connie: Now, why don't we move on to the spaced practice. Why is spaced practice better than mass practice?

Roddy: Let me first just define the term. Imagine you're reading a chapter, you could read the thing over three times in a row or read your highlights or underlines, because that's what students do as they say cram for a test, and actually it produces good but superficial learning. You can get through the test that way, especially if it's a multiple choice test, but if you ask people two weeks later, if you test them, they do much worse than if you spaced out the practice. What does that mean? Say you've got three shots at the material, if you do it one week, and then you wait one week and do it again the second week, and then you do it again before the test, those three presentations, especially if you test yourself afterwards and don't just read the stuff, that will produce

much more durable learning. If you test people a month later, that training regime, spaced practice, will produce much better retention than will doing the same amount of practice but all at once.

I find that people find that counterintuitive because…. Let me just give you one anecdote. One time I was asked to talk to a marketing class at the university where I used to teach, and they asked me a lot of questions about memory. What marketers and advertisers often measure is memory for ads, because it's hard to know if ads work because you're putting them all over the country. Sometimes they saturate St. Louis with an ad, but not Kansas City, and they watch how sales change. But usually an ad campaign is rolled out across a large areas of the country and they just measure 'can you remember the ad?'

So I turned the system around on them and I said, tell me one thing, when I watch, say, sports on TV, you'll often see a commercial for 15 seconds, then there will be maybe another commercial, and then you'll see exactly the same commercial for 15 more seconds. So, say, if you have a minute between the innings in a ballgame, you can easily see the same commercial twice. I said why on earth do people do that? And they said, well, we have a theory of learning and memory that says when you learn something, the best time to it hit it again is immediately after you've learned, it's already strong in your memory and that will make it even stronger.

And so I think that's kind of folk thought that lots of us have, that massing really is good, that you want to hit something again when you've already been exposed to it. But it turns out the evidence shows it's exactly wrong. The best time to hit it again is when forgetting has occurred, when it's not sitting there fresh in your mind, you learn much more when something seems somewhat novel, you just don't pay attention to something when it happens back to back. That is just very difficult to do. And so that's a kind of a folk theory of why this works. You just don't attend as well when something is massed, you think you already know it.

And one thing that has been shown by neuroscientist and psychologists is that novel events are well remembered. We even have a name for really novel events, 'flash ball memory'. I ask you to recount the day or where you were on the attacks of September 11th, a very novel event thankfully for most of us, most of us can give a pretty good account of our day that day, and how we learned the information. We remember seeing those horrific pictures on TV, and so there is a very distinctive event that we remember well. Well, ads and the stuff we're trying to learn are not going to be that distinctive, but if we have spacing between the presentations, they will be more distinctive. They will be

more different if we can space them out, and that seems to be why spacing works. And one difficulty in learning, what teachers want to do-- I talk to trainers in the military, I talk to sports coaches, what everybody wants to do is bringing you up to speed, suppose you've got five things you need to learn, so about tennis stroke, you've got your forehand, your backhand, your slam, a very natural way to practice is just do the same thing over and over. Well, let's practice the forehand 20 times, now let's practice the backhand 20 times, now let's practice 20 slams. And that is the way training happens in the military, you're bringing people up to speed, you learn fast, you get better. The trouble is that it's, again, if we go back to transfer appropriate processing, it's never the way you're going to need to use those skills. Your opponent is not going to hit you 24 hands in a row, you're going to need to be mixing it up, forehand, backhand, everything like that. So it's much slower to learn using mix or interleaved practice than using mass practice, and trainers don't like it, students don't like it, athlete don't like it, because it slows your learning. But what all the evidence shows for motor skills, and even some actually experiments with athletes, is you learn much better with interleaved and spaced practice than you do with mass practice, doing the same thing over and over again. Yes, learning is faster and it feels better with mass practice, but down the road you're much better off having spaced and interleaved practice, namely mixing up all the skills you want to practice.

Now, some mass practice might be okay at the very beginning just to try to learn the skill, but then you should be mixing them up. A much better way to practice tennis is to practice tennis the way you would play than to simply repeat the storks over and over, 20 to one side, 20 to the other, because you'll be practicing like you play. There is the comment is sports 'practice like you play and you'll play like you practice'. Don't do these artificial exercises very much. Some of it is inevitable, but you should really practice in a natural context. It's kind of like retrieval practice, you want to do the same thing you are going to be eventually required to do, so make your practice appropriate to the way you will eventually need to use the knowledge.

Connie: So, therefore, in workplace training, let's take eLearning, if someone wants to learn something or if there's a compliance course, they would take the course one time, and then perhaps take little bits of it, or little micro learning—I call that learning snacks—maybe in two weeks and then again in another two weeks. Just getting little bits of the information, is that what you're talking about?

Roddy: Yes. I think that would be great. Look on the internet and see SuperMemo, your listeners might be interested in taking a look at that. Imagine you're learning a big body of language, and what SuperMemo involves and their companies are based on the

similar principles, there's a company called Knowledge Factor, I'm on the scientific advisory board, but they have regimes of learning where you're tested on something you're supposed to know, you either get it or you don't get it, then you get feedback, and then you'll find a confidence rating, how sure was I about this when I retrieved it?

And if you're really sure, you might just click on the confidence… the computer program then pushes that way back, you won't be tested on that again for a while. But if you missed something and then you're given the feedback and you say I'm not very confident on this, then you will be tested on it again really soon. If you're medium confident, you get something right but you're not really sure, you didn't give a higher rating for your confidence, then you will tested on an intermediate level. So the basic idea is what you really know you'll be tested on less frequently, what you're struggling with you will be tested on more frequently, and once you get it then you will be tested less frequently.

And so it's a good general method of trying to program in the confidence in your knowledge. So you're not just taking a test on the same stuff, some of it you know very well, some of it you don't, so the idea is it's kind of like triage in medicine, you take the stuff you don't know very well and then you get quizzed on that more and you reread about that more, you might even be asked to reread the passage more. So that's one good way that these principles can be applied via learning, in fact have been applied, if you look around the internet and see all kinds of programs like this, some free, where you just type in the information you would like to know and the program will test you according to some schedule that the programmer has built into it.

Connie: I have seen a few programs like that. Can you talk a little about memory consolidation and how practice strategies support consolidation?

Roddy: Consolidation, there are two kinds, there is a fast acting synoptic consolidation, probably can't do anything about that, it's happening in our brain as you and I talk. And then there is a longer term systems consolidation, and I'm not expert on consolidation, again, coming into neuroscience, I've never done experiments related to this, but reading the literature one of the best things is simply sleep. Sleep and getting plenty of it helps memories to consolidate. And numerous studies show this now. And so the idea that we can have strategies that practice consolidation starts to be a relatively automatically occurring neural process. So the strategies like retrieval practice, well that probably consolidates, or rereading, that will consolidate too, it's just something is added over and above what rereading does when you practice retrieval. And I don't know of studies really looking at-- often consolidation is studied by having people take

naps during the day to measure consolidation during sleep that way, or in sleep labs over a whole night of sleep. And in some famous experiments you wake people up every so often and test them on whatever it is you've taught them before they went to sleep. So I'm not aware of strategies that would help you to consolidate more. It's more or less an automatic neural process that occurs in all of us throughout our lives. But sleep has been shown to have very positive effects on systems consolidation.

Connie: I just want to talk a little about what you call in the book 'difficult learning'. What is the advantage to making learning difficult, or perhaps you call it effortful?

Roddy: Desirable difficulty is a term coined by Robert and Elizabeth Bjork at the University of California at Los Angeles. And what they observed was that many studies, we really already talked about these principles, so you learn faster if you learn in a mass fashion. If you read something over and over, if you're tested immediately, you do really well, you do better than if you're quizzed, better than if you have spaced practice on an immediate test, better than interleaved practice. But only on an immediate test. And so if you do things like quizzing students or making them have spaced practice, or making them interleaf, those are all more difficult and challenging activities. The students don't like them because they don't do as well immediately afterwards. And they don't appreciate, in fact it's very hard to appreciate how it will help you later on.

So, for example, if I asked you or asked your listeners how well do you and I remember this conversation after a week, how well will your listeners remember this conversation after a week? It's a very challenging question, and it's what we really want to know, but many studies in psychology have shown that we're all very bad at predicting what we will know in the future. We underestimate the amount of forgetting that will occur. And so what interleaving and spacing and retrieval practice do is they help you retain things better over the long run, we've shown that in studies, but students have a very hard time appreciating that.

So the idea of making learning difficult just means something that slows down initial learning, makes it bit clunkier, harder for students to do, but it helps them much more in the long run. And the idea is that applying some effort into learning is going to help you in the long run. Learning can be hard, and making learning a bit harder in these ways, spacing, interleaving, retrieval practice, will really benefit in you in the long run even if you don't realize it when you're a student. And so that's the notion.

Connie: Does that also applies to, let's say, difficult problem solving?

Roddy: One things psychologists and educators used to really guard against was having students make errors. That's why they make things too easy. The idea is if they're making error they've create what's called a learning history of errors and remember their errors and think they're right, and say in problem-solving, oh, making an error, that's bad. Well, many of us have a revised idea of making errors. Making errors is just a natural part of learning, and if you really want to learn something well, say a challenging problem, the fact that you can make an error and then correct it yourself or have an instructor or a study guide or an online tutoring system help you to correct it, that's a very good way to learn actually.

So the process of having errors during learning, which you will in retrieval practice, you will by making learning more difficult, actually seems to be efficacious in the long run so you'll learn things better. I used to worry a lot about errors but now I don't so much, it just seems to be a natural process of good learning. And a number of recent studies have shown—somewhat to my surprise—that students don't really get bothered by their errors as much as many of us thought they would from the early opinion and research of psychologists and educators.

Connie: That is interesting. Before we wrap up, can you explain what neuroplasticity is and its relevance to adult learning?

Roddy: Plasticity refers to simply change, so neuroplasticity is the fact that the brain changes with experience. And that sounds like a commonplace, but for a very long period of time neuroscientist thought that the brain was essentially, say, after adolescence, pretty much fixed, the adult brain was pretty much there, all you were going to do was really lose neurons and lose neural pathways, so it's was all kind of downhill. And big discoveries in the last 20 or 25 years are showing that at many different levels in the neural system, from the neural level to a systems level of having interacting brain networks talking to one another, those can develop. That the adult brain generates new neurons in the hippocampus, one of our centers of learning. That's a relatively recent discovery.

A simple version of neuroplasticity is—unless we become demented or have some other incurable disease of the brain—we continue learning all of our lives. And we kind of know that, you can see people in their 80s and 90s whose minds are still sharp and they're still learning and reading and learning a lot of things. So at a simple level that's plasticity of the brain. It can continue through change. But at the neural level what they discovered, there's actually the genesis of new neurons and structures in the brain responsible for learning and memory. And that was a new discovery. And so that's what

got people excited. Say, a person has a stroke and loses some function, it used to be you try to do some things, but it's considered pretty hopeless, and now it's very still difficult but neuroscientists—and I'm not a neuroscientist, so I'm telling you kind of second-hand knowledge from my colleagues—now they're trying my other techniques to try to force the brain to reorganize itself. It has always been understood that when children have a brain injury, say, normally if you're a right-handed person, language develops on the left side of your brain, that's where the centers are, well for a right-handed child, say three years old, has a terrible injury to the left side of their brain, their language might develop perfectly normally, the right side will take over and language centers will develop there. That doesn't happen as easily in adults, and so many people are trying to develop—okay, the brain we know it's more plastic that we thought, what training regimes can we have that will permit people to regain function by somehow harnessing the plasticity in the remaining brain and getting those parts to do the functions that are now lost through the stroke or through the injury or what have you.

Connie: That's really fascinating research. I think that this conversation, your input, telling people about the myths of learning is going to really help all the people who design learning experiences do a better job. So thank you very much.

Roddy: You're welcome. I didn't really get into all the depths, of course we can't in a brief talk, but our book *Make It Stick: The Science of Successful Learning* came out two years ago, it was Harvard University Press, we go into a lot more depth there.

Connie: Right. I'll be sure to put a link to the book in the show notes. I found it to be excellent.

I hope you found this conversation as valuable as I did. I enjoyed listening to it again while I edited it. You will find the show notes at theelearningcoach.com/podcasts/32. Take care and I'll talk to you next time.