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CHRIS DAVIS: So welcome to the Career and Academic Resource Center Podcast. I'm your host, Chris Davis, the associate director of the Career and Academic Resource Center here at Harvard Extension School. Today it's my great pleasure to be speaking to Dr. Mark A. McDaniel.

Dr. McDaniel is a professor of psychology and the director of the Center for Integrative Research on Cognition, Learning, and Education at Washington University in St. Louis. His research is in the general area of human learning and memory with an emphasis on prospective memory, encoding, and retrieval process in episodic memory, and applications to educational contexts. Dr. McDaniel is the co-author of *Make It Stick: The Science of Successful Learning,* which was published by Harvard University Press in 2014.

And just a little overview of the book. Drawing on research performed over many years by a team of cognitive psychologists, including Dr. McDaniel, the book shares effective, evidence based strategies about learning meant to replace less effective but widely accepted practices that are rooted in theory, lore, and intuition. Translating cognitive science into educational science, the book is about, to quote from its introduction, "what people can do for themselves right now in order to learn better and remember longer." The book goes into some detail to address common study habits which are less effective tools of learning than what the researchers say is based on empirical research. Dr. McDaniel, thank you so much for joining me today. I really appreciate your time.

MARK MCDANIEL: Chris, it's great to be here.

CHRIS DAVIS: I was wondering in your words if you could talk a little bit about the research that preceded the writing and publication of the book and about your research and your work as well.

MARK MCDANIEL: Well, Chris, the genesis of the book, at most distal genesis, was volumes of research in the laboratory on how people remember and learn and retain information. Now, that research, as people might know who've taken a psychology class or a memory class, that research basically used impoverished materials like word lists or lists of paired associates.

This would be you're given one term and you have to learn the term that's associated with it and then you're given another term and another word that's associated with it. And these can be either word pairs. Early on they were consonant vowel consonant word pairs. So pretty impoverished materials and not much like what students are facing in their educational challenges and not much like what instructors are trying to teach, which is much more complex, interrelated, extensive knowledge domains.

So from that initial laboratory work, there was a group of us that with support from the James S. McDonnell foundation and Institute of Education Sciences that explored the extent to which the principles that were well researched from laboratory experiments could be extended to complex materials, biology materials, physics materials, chemistry materials, and the extent to which these principles might be usable, might be applicable in the classroom. Because a classroom is a very I don't want to say messy context. That may be too negative. It's a very complex context.

In the laboratory, what we're trying to do as memory scientists is to restrict the environment so we can identify one particular component that's involved in learning. Classroom, many, many components are involved. So it's a very clear question that when you extend your work into the classroom with so many variables involved, do these principles that have been isolated in the laboratory still carry some weight, have some effect?

So I'd say about maybe 20 years ago, maybe 15 years ago, there was a serious attempt to try to translate these principles into learning of complex materials and try to embed some experiments in the classroom. And after maybe about a decade of this, maybe from 2004 to 2014, we realized that many of these principles were quite applicable to the classroom. And in fact, many of these things we can talk about just a little bit are techniques for teaching, techniques for learning that are contrary to what our intuitions say ought to work. In fact, they're probably the opposite of what we would intuitively choose to do to try to learn or teach.

So we realized that it would be important if we could to communicate these results to a wide audience, an audience of educators and learners and parents and business trainers, military trainers. So the challenge there, Chris, was to try to figure out how to do this in a way that's accessible and not pedantic, not too dry.

CHRIS DAVIS: Well, I think that's a great segue to get into the meat of some of what you talk about in the book. Because I'm sure, as you can imagine, as someone in my role who one of the main things I try to do is to help students be better learners in the classroom and outside of the classroom. And you kind of get into both of that here, because you're talking about study strategies and you're also talking about classroom learning. But some of the learnings that you share in the book, some of what you pass along, and I'm not going to go through all of them because there's quite a few, but some of the key areas are learning is deeper when it's effortful.

I think one of the insightful things I found from reading the book is that, as you say, the research shows if it feels easy, then that learning is probably going to be superficial and is not going to stay with you in a meaningful way. We are poor judges of when we're learning well and when we are not. And one of the key things, rereading text, repetition, and massed practice of a skill, and the examples in the book that you give are not only examples of classroom learning but also sports training, military training, so learning in the more broad sense.

So repetition, rereading texts, are often the most common study strategies of learning. They are far from being the most effective. Retrieval practice, which is something you go into in a lot of detail in the book, is a more effective learning strategy than simply rereading. And spacing out that practice in longer intervals, between longer intervals or interleaving, produces longer lasting learning.

Now, the field of advising students on how to learn, one of the reasons I'm imagining you wrote the book, is that a lot of those quote unquote "best practices" are aging or based on research that just isn't there. One of the things that I really wanted to ask you more about to elaborate, because from students that I've talked to or worked with, I think this is-- and being also a school of continuing education, we have students who are closer to traditional college age, students in their 20's, but we also have students in degree programs who are much older. So sometimes they're bringing with them what they were taught decades ago.

And one of the things you talk about is, I'm quoting from the book, "We harbor deep convictions that we learn better through single minded focus and dogged repetition. And these beliefs are validated time and again by visible improvement that comes during practice, practice, practice. What scientists call this heightened performance during the acquisition phase of a skill momentary strength."

MARK MCDANIEL: There are really two points I want to make about that. And one is that this feeling, this judgment that repetition and mass repetition is effective is one that's very hard to shake, because there are cues that are present that your brain picks up when you're rereading, when you're repeating something that give you the metacognitive, that is your judgment about your own cognition, give you the misimpression that you really have learned this stuff well.

And two of the primary cues are familiarity. So as you keep rereading, the material becomes more familiar to you. And we mistakenly judge familiarity as meaning robust learning. And the second cue is fluency. It's very clear from much work in reading and cognitive processes during reading that when you reread something at every level, the processes are more fluent. Word identification's more fluent. Parsing the structure of the sentence is more fluent. Extracting the ideas is more fluent. Everything is more fluent. And we misinterpret these fluency cues that the brain is getting. And these are accurate cues. It is more fluent. But we misinterpret that as meaning, I've really got this. I've really learned this. I'm not going to forget this. And that's really misleading.

So let me give you another example. It's not just rereading. It's situations in, say, the STEM fields or any place where you've got to learn how to solve certain kinds of problems. One of the standard ways that instructors present homework is to present the same kind of problem in block fashion. You may have encountered this in your own math courses, your own physics courses.

So for example, in a physics course, you might get a particular type of work problem. And the parameters on it, the numbers might change, but in your homework, you're trying to solve two or three or four of these work problems in a row. Well, it gets more and more fluid because exactly what formula you have to use. You know exactly what the problem is about. And as you get more fluid, and as we say in the book, it looks like you're getting better. You are getting better at these problems.

But the danger is-- it's not danger. But the issue is that can you remember how to identify which kinds of problems go with which kinds of solutions a week later when you're asked to do a test where you have all different kinds of problems? And the answer is no, you cannot when you've done this block practice. So even though instructors who feel like their students are doing great with block practice and students will feel like they're doing great, they are doing great on that kind of block practice, but they're not at all good now at retaining information about what distinguishing features or problems are signaling certain kinds of approaches.

What you want to do is you want to interleave practice in these problems. You want to randomly have a problem of one type and then solve a problem of another type and then a problem of another type. And in doing that, it feels difficult and it doesn't feel fluent. And the signals to your brain are, I'm not getting this. I'm not doing very well. But in fact, that effort to try to figure out what kinds of approaches do I need for each problem as I encounter a different kind of problem, that's producing learning. That's producing robust skills that stick with you. And it illustrates exactly your point.

I just came across a paper in which this principle of interleaving was applied to a physics classroom. Homework problems were either presented in a block fashion. So that would mean three problems from one type of physics principle were solved in a row and then another three and another three. In another condition, students had these problems all mixed up. So by the third week of class, there could be eight problem types and the students are seeing those eight problem types intermixed. And at the end of the semester on exams in which the student's knowledge was assessed and especially the student's ability to solve these problems, the group that had interleaved practice, they were 125% better than students that had block practice.

But with the students who had the interleave practice, they incorrectly rated that as producing less learning than when they were doing block practice. So every student had block practice for half the semester and interleaved for another half of the semester. And when students were asked to rate which was the most effective technique to learn, they all picked block practice because it was easier. And we interpret ease as meaning we've really learned it well. So that illustrates exactly what you're saying in terms of the more difficult learning arrangement is producing the better learning. But students didn't rate that difficult arrangement as producing the better learning.

So this is a seductive thing that we have to, instructors and students alike, have to understand and have to move beyond those initial judgments, I haven't learned very much, and trust that the more difficult practice schedule really is the better learning. And I've written more on this since *Make It Stick.* And one of my strong theoretical tenets now is that in order for students to really embrace these techniques, they have to believe that they work for them. Each student has to believe it works for them. So I sometimes think-- I prepare demonstrations to show students these techniques work for them.

And then also hearing from high school instructors who have read the book and now they're using a lot of retrieval practice in the classroom. They have students produce answers to questions on whiteboards. Every student has a whiteboard and they're writing answers to the questions.

And then when the students take, say this is an AP class, take the practice AP exam and the students after doing lots of retrieval practice see how well they've done, these instructors tell me now the classroom becomes very exciting. There's lots of buy-in from the students. There's lots of energy. There's lots of stimulation to want to do more of this retrieval practice, more of this difficulty. Because trying to retrieve information is a lot more difficult than rereading it. But it produces robust learning for a number of reasons.

So I said I think students have to trust that these techniques-- and I think they also have to observe that these techniques work for them. It's creating better learning. And then you get-- then as a learner, you are more motivated to replace these ineffective techniques with more effective techniques.

CHRIS DAVIS: Right. In the book, I mean, some of what you talk about is from the pedagogy perspective in terms of how teachers and educators can approach sharing or teaching various kinds of content to their students. But you also dedicate time to talking about what can work better for the students on their end. And related to the research, I think one of the compelling narrative portions of the book is talking about, I think, if I'm not mistaken, it's a middle school that you and your team of researchers had worked with and how it was demonstrated, in fact, that more frequent and more casual kind of quizzing can be more engaging for students and also can help them retain the information and learn it more deeply.

And towards the end of the book, there's a section where you talk about tips for learners, how to make it stick. And there are several methods or tips that you share: elaboration, generation, reflection, callibration, among others. I was wondering if you could talk a little bit about which of those steps you think is most beneficial. And also if you could talk a little bit more about-- because one of the-- as I said, one of the key aspects of the book is how quizzing and testing and self quizzing, self testing, and spaced out at longer intervals can be so effective. One of the phrases that comes up in the book several times is when you're rusty with certain information and you're working to really retrieve it, that can feel not great, but it can also lead to deeper learning. So I'm curious to hear more from you about that.

MARK MCDANIEL: Well, I guess you pose the question of which of these techniques might be better. And I would say it depends on the learning challenges that are faced. So retrieval practice, which is practicing trying to recall information from memory, really super effective. If the requirements of your course require you to reproduce factual information. So on one course that I know about, the students have to be able to see a list of prominent scientists' names in that field and be able to tell on the exam what contribution did this scientist make to that field.

Well, in that case, retrieval practice is really very helpful, because the requirements for your criteria tasks, your test, are to retrieve information about the scientists when you see the scientists' names. So the age old technique of making up flashcards where you have a scientist's name on one side and you try to recall with that scientists did and then give yourself feedback by looking at the back, it's very effective, much more than rereading the scientists and what the scientists did.

For other things, it may be that you want to try something like generating understanding, creating mental models. So if your exams require you to draw inferences and work with new kinds of problems that are illustrative of the principles, but they're new problems you haven't seen before, a good technique is to try to connect the information into what I would call mental models. This is your representation of how the parts and the aspects fit together, relate together.

So for example, if you're trying to learn how brakes work, well, it's not enough just to know the parts of the brakes. You have to learn how those parts interact and you have to know why those certain interactions create a brake pad coming against the brake drum and stopping the car. So here we've also in experiments we've done retrieval practice with these kinds of materials.

And people can recall the content quite a bit, but it doesn't necessarily improve their ability to solve problems about brakes. So one of our problems might be it turns out that you're pressing the brake pedal and the brake pedal is pushing down, but nothing's happening. The brake's not working. What's wrong with it? How would you fix it? So that's never discussed in the content. But if you have a good mental model of how brakes work, you'd be able to give a pretty good answer to that question.

So what happened there, the better thing is to try to get people to explain, to think about could I explain how a brake works to somebody else. And if people are reflecting on whether they could do that as they're rereading the passage, they start to develop a good mental model. They start to learn about how brakes work and then they do better on problem solving. If we give them schematics that show how the brakes and brake parts interrelate and work together, they develop better understanding and then they solve these problems better.

So sometimes what students need to do is push to try to answer for themselves why? Why would this be the next step in a problem? Why would it be the case that when you step on the brake pedal that something happens so the brake shoes clothes on the brake drum? So another technique is to self explain. Retrieve in some cases is effective for retention. Self explanation is awfully effective for understanding and being able to generate inferences.

Spacing out these exercises, explaining why, a retrieval practice, produces more robust memories that are more generalizable. We go over a lot of examples in the book. And so I think it's not that one technique is better than the other. It's that different techniques produce certain kinds of outcomes. And depending on the outcome you want, you might select one technique or the other.

The other thing I have to say is I really firmly believe that to the extent that you can make learning fun and to the extent that one technique really seems more fun to you, that may be your go to technique. I teach a learning strategy course and I make it very clear to students. You don't need to use all of these techniques. Find a couple that really work for you and then put those in your toolbox and replace rereading with these techniques.

And that's what my students say when I survey them six months after the course is over, at least half of them say, I really found spacing to be very effective. It's my go to strategy. And by the way, I'm now admitted to graduate school in theoretical math. I use spacing very successfully over my past two years. Somebody else really likes mnemonic techniques for learning factual content they have to learn. And that was something that they enjoyed doing and it turned out to be very effective.

Somebody else talked about using retrieval practice as their go to technique. Somebody else talked about generating an understanding. And one of the ways you can do that is try to learn sufficiently that you could teach somebody else about the lesson. And so some students embrace that. They say, I try to teach other people and it turns out I really understand the material much better. So I would hesitate to say one technique is better than the other. I would like to say that some techniques seem to be more attractive or fun.

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I just the other day was talking to the first year physical therapy people at Wash U. And when I talked to her at the beginning of the semester about using retrieval practice and I encountered the student again last week and I said, well, how's the study going? And she said, well, what I do is we're in anatomy and we got to learn all the parts of certain systems.

And she said, what I like to do is I like to-- it turns out she could purchase a book that has these different anatomical parts and she likes to color them and then try to retrieve what they connect to and what they do. And she said, I do that because I like to color. It makes it fun. But she's embedding this in a retrieval practice exercise. So just an illustration that all these techniques can be successful. The one that you must enjoy or the two that you must enjoy, certainly you should embrace those. Try to use them.

CHRIS DAVIS: And in closing, I couldn't help but want to ask you, because as you can imagine, this is something that's close to our mission, you in the book reference lifelong learning and lifelong learners. And reading the book, you talk about the brain being plastic, mutability of the brain in some ways, and giving a few examples of how some lifelong learners approach their learning.

And so I was wondering in closing if you could talk a little bit about that, what you think in terms of-- because I think there's a reference also in the book to there being a perception that our intellectual ability is hardwired at birth and how with new learning, you're changing the brain. I found that very intriguing.

MARK MCDANIEL: First of all, I'd like to say that in some sense, more mature learners, older learners, have an advantage because they have more knowledge. And part of learning involves relating new information that's coming in to your prior knowledge, relating it to your knowledge structures, relating it to your schemas for how you think about certain kinds of content. And so older adults have the advantage of having this richer knowledge base with which they can try to integrate new material. So older learners shouldn't feel that they're at a definitive disadvantage, because they're not. Older learners really want to try to leverage their prior knowledge and use that as a basis to structure and frame and understand new information coming in.

But the other thing, I think the emails I get, and I get a lot every week, I just got one from a teacher who was talking in the email about reflecting on his own experience learning guitar and ancient Greek and philosophy and theology and thinking about how he had done that. And he said, a lot of people try to approach this with the accepted theories about how to learn, repetition and studying a lot at once and cramming and so on.

And he said, I felt flummoxed and trapped about trying to learn as an older learner using these old theories. And he said, thinking about the techniques in *Make It Stick* made everything fall into place. And I started to understand what I was doing right in learning these things and maybe what it wasn't doing. That's the gist of the message.

So the idea is this. Is that part of possibly our challenges as older learners is that we do have these habits of learning that are not very effective. And it's easy. In fact, that's what everybody does. We turn to these habits. And if these aren't such effective habits, we maybe attribute our failures to learn to age or a lack of native ability or so on and so forth. And in fact, that's not it at all. In fact, if you adopt more effective strategies at any age, you're going to find that your learning is more robust, it's more successful, it's more-- it falls into place, as this person in the email said.

So Chris, I guess one of my big points, one of the big things I try to emphasize is, at any age, you can learn these strategies. But especially I think for the younger students, it would be a great idea to try to start developing these effective strategies early on so that they do become a habitual way of learning. And then you have an excellent foundation for lifelong learning, effective strategies that you can apply to anything you might want to learn. Foreign languages, playing a musical instrument, taking new courses in a field that you're not familiar with. So I just think that knowing about these techniques unlocks so many avenues as we continue through life for being open to learning, being successful for learning, being confident that we can learn.

And I'd like to say it really was reinforced, this was reinforced by a student of mine that I had at my learning strategies course who came into my office the summer after the course. And he seemed very up, very excited about the school year. And I said, well, what's going on? Tell me what's going on? He said, well, he said, I now know that I can meet any learning challenge that I'm going to face. I now have effective techniques for doing that. And I'm just so excited to get back to classes. And that's what I think these techniques can do for people is that it can make them excited and confident that they can meet any learning challenge and that that learning challenge now becomes enjoyable. So I think that's part of lifelong learning is getting these effective strategies in place, trusting them, and having them become a habit for how you're going to approach your learning challenges.

CHRIS DAVIS: I do hope that students who are interested in and committed to improving their learning strategies take a look at the book. Because yes, I think there's something in there for everyone. And I think having read the book, there are certainly very practical tools and advice and guidance and real life examples that can, I think, benefit most learners who are reading it and trying to discover what learning strategies, study strategies work better for them. So I want to say thank you on my behalf and on behalf of our students as well.

MARK MCDANIEL: OK, Chris, can I say one more quick thing?

CHRIS DAVIS: Sure. Yes.

MARK MCDANIEL: And that is that I think one of the fears of students is that if I start to use these learning strategies, it's going to take me even longer to study. I'm going to really have to spend more time. And I wondered whether that might be the case. My students are telling me that's not the case. My students are telling me that they're not spending more time studying, but instead they're taking effective study strategies and using those instead of their less effective strategies that they had relied on for so many years, which was lots of rereading, lots of reviewing.

And in the final analysis, the net is that students aren't spending more time. Instead they're spending more effective time. They're working better. They're working smarter. And I think that's also something for all of us to keep in mind is this doesn't mean you have to commit lots of extra time. It means that instead you're doing things more effectively in the time you're spending. I think that's very positive.

CHRIS DAVIS: I think you're right. And if anything, I think one of the examples that you talk about is the practice of cramming before a test or before an exam. I think the strategies should make you think about how to study maybe earlier than you otherwise would and to have a plan that's kind of more active rather than reactive. But it's certainly less effort and effort spent more wisely than spending the days or hours before a test cramming and rereading. That's quite time intensive and probably not a great result. So yeah.

MARK MCDANIEL: Yeah. That's an excellent point, Chris. Just an excellent point.

CHRIS DAVIS: Well, Mark, thank you again for your time so much. I really do appreciate it.

MARK MCDANIEL: It was great being here, Chris. Just really enjoy talking about these kinds of things, and my goal is to help people become better learners and enjoy it more.

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CHRIS DAVIS: You have listened to the CARC Podcast. This is the podcast for the Career and Academic Research Center here at Harvard Extension School. And I hope you will join us again.