



Webinar with Matt McCrudden

School resources

Associate Professor Matt McCrudden worked at Victoria University of Wellington for ten years and now teaches in the educational psychology department at Penn State University. In this webinar he talks to Dr Nina Hood of The Education Hub about his research into the science of learning and how teachers can apply the principles of learning science in their classrooms.

Nina: Good afternoon everyone. My name is Nina Hood and I'm the founder of The Education Hub. And it's my real pleasure to have Matt McCrudden here, this afternoon for us, but it's the evening where he is. He's an Associate Professor at Penn State University, having moved recently from Victoria University in Wellington. He is an expert in all things learning and the science of learning, and for the next probably about 45 minutes he's going to be sharing his wisdom and knowledge with us. So welcome Matt, thank you for joining us, and the first question we have is: What do we mean when we talk about learning and student learning?

Matt: Tena koutou, it's a pleasure to be here, thanks for the invitation Nina. So, what do we mean by student learning? I'll start this out for folks giving it a little bit more background too, that I have worked at Victoria for 10 years before moving back to the US. You can tell by my accent that I'm not originally a Kiwi, but we were there long enough that we are now Kiwis. So, I'm going to draw upon some of the responses based on my interactions with teachers and also people who are students in my postgraduate classes, in particular, in classes I taught in the Educational Psychology program at Victoria who were classroom teachers, and also my opportunities of being involved in classrooms in schools in New Zealand, in Wellington in particular.

Now back to the question, **what do we mean by learning?** What I would try to do is frame this by thinking about three basic concepts. The first is **Comprehension**, the second is **Memory**, and the third is **Learning**. These concepts all relate to each other in the sense that:

- **Comprehension** pertains to a person's ability to follow a story or to follow an overall message;
- **Memory** is a person's ability to retain that information over time; and then
- **Learning** is a person's ability to use what they've learned previously or what they're currently learning to do something or to come up with a new idea.

So when we think about learning it's not just what can a person be able to know about or be able to do as a result of instruction, but it's also thinking about, at the time of learning, can people comprehend what's happening, over time can they retain that, and then later can they use that, or does that modify what they do in the future? So, broadly speaking, I would say that learning is being able to know or do something that you couldn't do before some sort of instructional episode, but also thinking about this idea of comprehension.

Because sometimes what students do, and learners in general, will say 'I comprehend what's happening right here' and they'll take that to be evidence of learning; and then they won't do anything more because, 'if I follow what you said, that makes sense; if it makes sense that means I'll probably remember it; and therefore I've learned it'. So it's thinking about how we define learning but then also how students interpret whether or not they have learned something and the cues that they use. And sometimes the

cues that they use aren't necessarily always adequate for knowing whether or not learning has occurred. As I said before, sometimes people say 'I understood that, I comprehend what you said, therefore I will learn it'. But that's not always the case, so it's important to think about learning as a person comprehending what's happening; being able to retain that over time; and then later to be able to use that. So I like to think about it in that way.

Nina: That's really interesting. There are two key threads that I'd like to pick up from what you've just said. One is the focus on teachers, and the other is on students. So if we start with the teacher side of it - what are the key things that you think teachers need to know about Comprehension, Memory and Learning, and in particular the processes that go behind and sit underneath those three concepts?

Matt: So you're saying what should teachers know about those things? So the first thing that comes to mind (this is not going to be earth-shattering) is that learning isn't easy, that it generally takes time and energy, not only on behalf of the teacher which I'm sure I'm preaching to the choir here, but also from the student standpoint.

One of the principles I go back to is the idea that, from an instructor standpoint, **just because we communicate an idea clearly, it doesn't necessarily mean that students actually either comprehended it or that they've learned something**. So when I say comprehending it – what a teacher can do is just ask. So there's the **intended message** that the teacher may have, and then there's the **meaning that the students themselves create**, and this is oftentimes a **function of their previous experiences**. And, as we know, a teacher's experiences may not always match that of their students. And so it's important to be aware of the assumptions that we make about how people learn, or what we think they're comprehending. And just basically **checking that on a regular basis** to see - okay, do they understand it in a way that I'm hoping they understand it? And so one way we can do that is like a perception check. Ask them - so what does that mean to you? Do people understand?

And then related to **memory and learning** ... from the **memory** standpoint - it's important to understand how memory works and being aware of what over a century of research on memory tells us, is that initial **exposure** to content and a person's **ability to comprehend** information **does not ensure long-term retention**. So going back to this idea that we need to understand how the mind works, so the architecture of cognition is that it's important to have planned redundancy in content. So revisiting ideas spread out over time.

Cognitive psychology has a term for that, which is **distributed practice or the spacing effect**. Essentially what that means is that when people encounter information multiple times there should be time gaps in between that. What that does is allow ideas to become active in memory and then over the passage of time they become deactivated and then later on become reactivated. So those cycles of **activation, deactivation and reactivation** are things that support long-term retention. In part, because it strengthens the retrieval structure, it strengthens our ability to re-access information later on. So that was it for a teacher standpoint.

But I also relate to that that it's not just the presentation of information but also **what students generate during learning episodes**. So them creating meaning from what instructional message they're receiving, but also enabling them to access their prior experiences during that learning episode so they connect what you want them to learn or you want them to know with what they already have retained in memory. And we know that when we're able to connect what we're learning to what we already know, that helps support long-term retention and our ability to use information at a later time.

Nina: And I think those ideas of revisiting key knowledge and content that you're doing over an extended period of time, and also thinking about how we can support the retrieval practices of students in their

learning journeys, are really key ones. Are there any things that you know from your own research and work, and also your work with students, that teachers can do to support the retrieval process?

Matt: I'd say there's probably **three basic ideas** that I think are very straightforward and accessible. And when I've given presentations to teachers a couple of comments come up. One is 'I do some of those things, but I didn't realise there was a name for it' and other times it can be like 'oh, I've heard of some of that, but not all of that. That's helpful, those are things I can really add quite easily to my classroom'.

Distributed Practice

Essentially I mentioned one of them before which is **distributed practice and that is revisiting content periodically over the course of a term**, a school term, the idea being that, again, when we have multiple opportunities to think about content, we have that process of activation, deactivation, reactivation. So distributing that practice over time, spacing out those learning episodes and so having more short episodes rather than long spread out episodes. So having multiple tours of that content.

Retrieval Practice

The second one is related to that. The term used is **retrieval practice**. Retrieval practice is essentially **encouraging students to generate ideas from memory**. And to think about this, let's say you have a student who is studying, to keep it in a concrete example. It's common that students will reread and rewrite their notes or reread text, after having read it once. So that is repeated exposure to content. But one of the things that we're thinking about how people retain information over time, and subsequently being able to use it, is that there's some things called desirable difficulties. That is asking students to try and recall information before they get feedback on it, before they re-study something. And the process of attempting to have to reconstruct memory, even though it can be difficult, can in the long term help with the retention of that information. So it sounds a bit counterintuitive and that's what we call a desirable difficulty, that having students experience a degree of difficulty, and be able to re-access information, that process actually strengthens learning.

So that was originally called the testing effect, but researchers have moved away from that name because the word 'test' has so many negative connotations when it comes to an assessment standpoint. But when we think about retrieval practice, doing things like starting out class by asking students 'what were two key things that you learned or you remember from yesterday's class?' Or, at the end of a class, 'okay let's stop for a moment. I want you to generate two key ideas that you've learned today, and then after you've done that, share that with somebody else and see how they compare'.

Essentially getting people to **take information that they may have comprehended and see if they can re-access that**. So that's the second principle. The first one is **distributed practice of spacing out our episodes**, and then as we spaced out the episodes also include opportunities for **retrieval practice where you pose questions of students and they have to generate responses**. An important part of that too, in an applied setting is **providing feedback later when students have attempted to generate those ideas**.

Elaborative Rehearsal

The third one is something called **elaborative rehearsal**. This one is something most people are familiar with. That is to **ask students to leverage their existing experiences, their existing prior knowledge, to make meaning of ideas**. And what that essentially is doing is encouraging them to access their prior knowledge and their prior experiences and connect that to what they're learning.

So when you combine all three of those you have **distributing practice over time, asking people to retrieve ideas from memory**, but also then to **connect ideas already known to what they're learning**. Those three things from a cognitive standpoint are very effective at helping students become fluent with those ideas and then use them later on. So that it might be a bit slower from the start but later on students are able to switch in and out and more flexibly apply concepts or conceptual knowledge.

Nina: Thank you for that. I want to go back to what you talked about at the beginning, this idea of comprehension, memory and then learning and the idea that learning is to be able to do something with what you've previously learned and actually put some sort of action behind it. I think one of the things that is often discussed in education in New Zealand is this idea of really focusing on getting students to do something. It could be around ideas of inquiry or problem-based practice or actually utilising knowledge and ideas to produce something. Are you suggesting that before you can really get to that learning phase you actually have to go through the comprehension and memory phases, so that you actually have a quite strong, robust knowledge of something before you're able to do something with it?

Matt: Well, I think that not always, but sometimes yes. So I think that there's times when ... we can think about the contents of our memory as falling into three different bins.

Declarative (Semantic and Episodic) Memory/ Procedural Memory

So let's say we have something that's called **Declarative Memory**. **Declarative Memory is, essentially, things that you can say**. And the other side of that you have something called **Procedural Memory, and this is things that you can do**. So I said there's three ... declarative is broken down into two categories. So we have something that's called **Semantic Memory - and this is just basic memory of the facts**. This is commonly the type of thing that we learn in a school setting. So Wellington is the capital of New Zealand; a tuatara is a reptile but not a lizard. So those types of things.

Whereas **Episodic Memory** – another type of **Declarative Memory** – is **experiences that students have actually had** in their own lives where they are an actual part of that memory. So, what did I do for Christmas holiday last year, or where did I grow up, what are some of my favourite things to eat, what are my interests, something along those lines.

So we have those **three types of memory**. We have **Semantic Memory**, which is general knowledge about the world; **Episodic Memory** which is experiences that people have from their lives; and the **Procedural Memory** is how to do things. If we think about those three categories, and also think about what do we want students to be able to know, or do. We think about, if we want to be able to know something, let's say form a Semantic Memory (that's general knowledge about the world) - how can we connect that to what they already know - that is their Episodic Memory? So how can we take those experiences that they already have and give labels to some of those things? So what I'm getting at is there's times when students have practical experiences in their lives they can use to relate to things. And so, when we talk about how much experience do students need to have, or if they have to have something in memory before they can actually use something, in general I would agree with what you're saying Nina, and that we need to have something in memory. But there's times when we have those experiences, but we can't provide the labels for it. Or we don't have a way of grouping that in a way that we can say, 'well, this is something that's relevant, this experience that I have is relevant to what you're talking about now'. And so they may not have the formal knowledge that we are asking them to understand. But they may have had experiences that relate to that.

But when it comes to procedural knowledge, that and Procedural Memory, one of the things we want to think about is our ability to develop skills to the point of **automaticity**. What automaticity means is

being able to do something that requires limited effort. So when it comes to typing for example: when you are first learning how to type, you may need to look at the keyboard quite frequently to know what buttons to push. But later on, when you develop something to the point of automaticity, you don't have to necessarily think about that. You can think about the message you want to write with that. So we have developed fluency or automaticity with respect to typing, with writing, with reading, to be able to apply procedural knowledge for doing mathematics problems. An example I talk about in my classes is when I used to be a lifeguard. We're teaching people how to do CPR for example. We can't just stop and say 'okay, all right, let's see here, how do we do this again?' No, you have to have developed that to the point of automaticity so when you have to use it it's available. Because you don't have the time to be able to stop to look at things.

So tying this all back to your original question - do students need to have that in memory? Generally **speaking they have to have some sort of knowledge base to understand** the topic and what you're wanting students to be able to do. And they **have to develop some skills to the point of automaticity** so that the act of doing some type of procedure doesn't use up space in their limited capacity of the focus of attention, so that they're not distracted by doing the task. They can think about 'well how do I make meaning from this?' And another straightforward example I'll share is that when people develop automaticity with respect to reading. So imagine you have a very simple view of looking at reading, that people are doing two things, that is, decoding and comprehension. If decoding is not developed to the point of automaticity, then there's limited space available for comprehension processes and for processes involved with making meaning. So as a general statement I would say that it's a good idea for students to have developed skills to the point of automaticity, and that the students have some degree of fluency with respect to using terms. But I don't know it's necessary to have them memorise words before they can apply them. I think that they can be introduced in the ideas and asked to use and develop conceptual knowledge, but then do that periodically over time where they have that, again the re-exposure, planned redundancies where you have deactivation and reactivation. I'll leave it at that.

Nina: That's brilliant, thank you. We've had a few questions come in from people watching. Brendan asks 'what is the science behind students articulating the next steps in their learning? How does this help students to learn, or in fact does it help students to learn to be able to articulate the next steps in where they're going?'

Matt: The first term that comes to mind for me for that is metacognition. I'd say that's crucial in the sense that they're not just sort of stimulus response creatures moving from one space to the next. It's being able to **understand what they're doing and why**. So I'd say this is very important. So you have this idea of **metacognition, which is being aware of how our mental processes influence learning**. Knowing what to do to influence their learning, for example, when they don't understand something, and then knowing when to apply certain strategies where they don't understand something. So I'd say that's something that's generally quite important. Because ultimately what we want to be able to do is to enable students to be able to regulate their own learning. And so part of their ability to regulate their learning is understanding what they're doing and why. And when they encounter difficulty, how can they overcome that? And that might be using a comprehension strategy, using some memory technique or even potentially saying 'I don't understand this, I need help'. So I'd say that's a great question along those lines.

Nina: That brings me back to something that you said earlier about the importance of how students interpret that whether they have in fact learned something. Are there any things that you think teachers can do to support students in actually understanding the learning process, and whether they have in fact truly learned something?

Matt: I'll speak to this from a standpoint of me being an instructor. I'll do demonstrations in class to show students that their memories aren't as good as they think they are. So it's quite common for students to have sort of an intuitive belief that memory works like a recording device, that I've had this experience, it makes sense, therefore I'll remember it. If I can't remember it, it's because I didn't repeat it enough. And you can see this belief when we think about the courts, or when we're asking people to retrieve some sort of memory in a law case for example. Where there's this perception that someone had a very traumatic experience or something happened in an event, like that's something you should really remember. But it turns out that you have people who have had the same experience who have much different memories of that. Lots of different things happen to create memory, and also we have reconstructive processes that we engage in when we try to remember something. So what I try and do is I have a number of activities where students ... I'll give them data of their own experiences and say 'well, how do you interpret this? Does this mean that memory works like a recording device?' And so what I find is that if I just say to students 'oh here's a study by so-and-so and here's what they found' and the results are counterintuitive, they may not actually believe it and it may influence their behaviour. So I have them do things like experience what happens when you just read information versus have to generate information – how does that influence your ability to remember it a minute from now? And they're always struck by it. And so what I try and do is have them experience some of these ideas, have them see the data and interpret that and give them a framework for understanding what that means, and then how do we then take that forward? How do we use that, how do we apply that information? So I'm hoping I'm not speaking about that too abstractly, but certainly if you want more I can go on, but I'll leave it at that unless you want more.

Nina: No that's great thank you, and I think some of the ideas that you're talking about in this, like the notion of how people learn is, somewhat ironically, not always particularly well covered in teacher training in this country. And I know certainly for me I didn't really start to engage with this literature and these ideas until I did postgraduate study in education. So I would just be interested in your thoughts on what some of the ideas are that you think should be included in teacher training or ongoing teacher professional learning to support what teachers do in the classroom around enhancing student learning?

Matt: Sure. I can answer this in two ways. One is to sort of bring back some of those ideas I talked about before, that is using that distributed practice, using retrieval practice and having students use their prior knowledge to elaborate on ideas to make it meaningful for them. When I was teaching post-graduate classes, particularly those who were classroom teachers, they really latched on to that, particularly when we'd go through examples.

The other way I'd go about answering that, so I'm not being too redundant, is **understanding the nature of the learner**. Because often times, at least based on my experience, is that in teacher training what we, and when I say we, at the university, oftentimes are doing is trying to say 'here's how you go about teaching math' or 'here's how you teach English, or reading, or writing'. Whatever it might be, there's certain assumptions that we hold about how people learn. But it's also understanding that it's, how do we also have an understanding of who are the learners? So adapting our instruction to make sure we meet their needs.

But to bring this back to a cognitive standpoint, because you could go with a whole different bunch of directions with this, but basic things like – understanding that we have a limited capacity to think about anything at any given point in time. So this assumption that there's a limited capacity, and how people use this information from a cognitive standpoint, that's very similar to the Holy Grail. That what happens at the time of learning influences our ability to retain and use that information later on. But the caveat

is you also have to connect that to those three ideas I mentioned before - distributed practice, retrieval practice and elaborative processing.

So we have that limited capacity - what we do with that is crucial. That duration is limited, we can only think about so much at one time. So most teachers have had this experience, particularly in a primary classroom. It's also the case in secondary classrooms as well. But if you give students too many instructions, they lose track. The basic idea is that they can't follow everything at once. The analogy is like taking a drink out of a firehose - you might catch some of it but a lot of it is going to go past. You're not going to retain it. So **making sure that we segment instruction in digestible bites, so to speak, and enabling the learners to use their existing knowledge base and resources to make meaning and later to develop automaticity in using different types of skills.** So that was kind of a long-winded response, Nina, but that was how it came out from my cognitive standpoint.

Nina: That's great, thank you. Going back to a question asked by one of the people listening in - this is around the sharing of learning intentions with students, and whether you have any thoughts about whether it is an effective practice to share with students at the start of each lesson what the learning intentions are.

Matt: That's a great question too. What I'm thinking about that is from an instructional design standpoint - what teachers are being asked to do in order to prep for a lesson. I think that it can be valuable based on how it's done. When we as educators develop intended learning outcomes, we may use action verbs or rely on something like Bloom's taxonomy to come up with what we want students to be able to do. If they don't understand what those terms mean, then I would say that the instructional value of that is going to be somewhat limited.

But that doesn't mean that a teacher shouldn't aim for the **alignment between the objectives, the class activities and the assessment.** So I think that from a teacher's planning standpoint it's valuable to have that alignment - essentially saying 'what do I want students to know or be able to do at the end of the instruction?' So laying that out - what activities can help students to master those objectives, and then how do I know if they reached that? How will I assess whether they've met that?

So there's value in having that, but I think that what I've found, particularly in my own research, is **giving students pre-questions.** So: 'we're going to be talking about X today, so as we do that I want you to focus particularly on these types of things'. Science teachers would be familiar with the **Predict / Observe / Explain** sequence for teaching.

I'm trying to **draw the learners in from a content standpoint so that we can potentially engage their situational interests, or prime them to be looking for certain types of things during an instructional episode.** I find that to be beneficial for gaining and maintaining student attention.

I realise that's a bit of a hornet's nest stepping into from a teacher standpoint. We're being told 'here, do this'. I think that it can be beneficial, but also how you do it influences whether or not it's going to draw the students in and how it helps them focus their attention during learning. A simple way of doing it is maybe asking them questions they may not be able to answer before, but it helps prime them to be looking for those types of things during instruction.

Nina: Great. This is a question that wasn't on our pre-approved list, so I apologise if it's a bit out of left field. There are a lot of what I would call 'learning myths' that seem to be floating around education at the moment. Are there any learning myths that you think you'd really like to sort of see be completely shut down and people no longer actually believing them or utilising them in the classroom?

Matt: You said there's lots of them out there. I think, rather than answering on 'is there a specific myth?' I would say it's important to look at the research base. I'm not saying that's the only source of knowledge that we have - I don't mean to diminish the value of our practical experiences in everyday lives - but I think a big thing is to look at what evidence supports what's being done.

I'll give you a New Zealand example that I'm familiar with recently, and that is - after the Christchurch earthquakes there was an opportunity to rebuild schools, and the idea of not having any walls, just having open spaces. I've had teachers who've been in those schools, and even some in Wellington who have gone on those lines - that millions of dollars have been spent to develop these classrooms, but we don't know if that actually helps. And when I come at it from an attention standpoint, some students may find it particularly distracting to be in an environment where you don't have walls. So I don't think the presence or absence of walls is necessarily some magical equation for learning. I think with everything it's a matter of how is it implemented, what is done. So some of the teachers at a school in Wellington would have spaces where students could go that were quieter, or that would separate them from others, because they found it a bit overwhelming to be in that type of a context.

And so I think in general sometimes we're in a rush to get to the new exciting thing, like brain training or working memory, trying to increase students' working memory capacity.

Another thing is being aware of the evidence that supports these changes, and I'm not really aware of a lot of evidence that went into the idea behind, for example, the open classroom environments. Doesn't mean it's not working, it just means that we need to, when we're making these decisions or choices, think 'what does the evidence tell us about this?' And also being mindful that research isn't flawless, and we know you can't turn to research for everything, but it's better making an assessment on the evidence of research rather than just purely on what we think might happen. Are there any particular myths that you'd like to discuss at all from a cognitive standpoint, that you think you'd like to have a reaction to?

Nina: Sure. Well there's one from me that I recall very clearly from my days of initial teacher education, where we were told about learning styles, and that we were going to have some children in our class that were just kinaesthetic learners and therefore we had to cater to them in that way. I think that there's probably a lot of research that's come out that has suggested that this idea of learners just learning in one particular learning style is not necessarily founded in huge amounts of research evidence. I don't know whether that's something you could talk to.

Matt: Sure. There was actually a review article in, might have been in *Current Directions in Psychological Science*. I can't recall exactly, but in my area, in educational psychology, there's a tendency to respond to that and say, 'well, we actually don't have much in the way of evidence of anything to show that learning styles exist'. And so how you typically go about doing this from a research perspective is, you'd classify students as a type of learner - as taking a certain approach to learning - and then providing instruction for some students that's compatible with that style and for other students that's incompatible with that style, and seeing if there are differences in learning. So when you mesh the instruction to the style, versus having incompatible instruction with the style, are there differences in learning? So if learning styles exist, then what you'd predict is that, when you mesh it, those students should do better than the students for whom you don't mesh it. And when those types of things are designed, it typically doesn't matter.

I think that the more important thing that I walk away from that literature on is **that good teachers use a variety of instructional techniques and they do that based on what they want students to be learning about**. And so we don't use the same approach to instruction independent of the context. So if I want students to learn how to swim I can certainly talk about it, but it's probably better to get them in a pool.

That doesn't necessarily make them bodily kinaesthetic learners - it means that I want them to learn involves physical activity and the more experience and practice they have with that, the better they're going to become. So from my perspective whether or not learning styles are real is less important than making sure that the activities that you're asking the students to do support the intended learning outcome that you want them to be able to do. So again, have that instructional alignment.

Nina: Yes, and I think you raise a really interesting point there, and it's coming through in a lot of things that you say, about making the learning fit the particular context, and that a real focus on how the different activities and tasks are implemented and what is actually done is going to be key in terms of the learning that occurs.

And just one last question to finish up, because I realise that it is getting quite late at night for you – what are some of the most interesting things that you see coming out of the Cognitive Psychology research at the moment?

Matt: I'd say there's two things. Earlier in the discussion we talked about having students generate ideas during a learning episode, and how that can support their ability to retain and use content they're learning at a later point in time. Something that I think that I've really found quite fascinating recently is, with the developments of MRI and different neuro psych techniques, that we're able to look at changes in brain patterns and regions of activation based on the types of activities that the students are being asked to do. So you see different regions of the brain activated when students are asked to generate, versus reread something for example. And so what's interesting about that to me is that you have multiple lines of research converging on a common point. So **one basic principle is the generation effect - asking students to generate ideas and asking them to retrieve information for memory strengthens learning.** And to see that from a measurement standpoint and from 'oh, here's what happens during a learning episode' and then measuring differences in learning based on what students did or what they said they did. And I also bring in some of the neuro psych stuff to say, 'well, here's differences in brain activity'. I find that that's pretty fascinating. Now I don't have enough background to interpret what's happening, so I'm having to rely on people who have more expertise than me, but that's been quite fascinating to me as far as what are some new developments that are happening. Now there's not much we can do about that from an instructional standpoint, other than, if we're asking students to do certain things, that there's more support that that does work.

I think that the major development that's happened in the last ten years, and this will put me in the camp with Cognitive Psychology, is this idea that **having students do retrieval practice helps them learn. It also facilitates transfer.** And the reason I find it such a curious finding is that it's so counterintuitive to students. They just reread and rewrite their notes as opposed to actually trying to do some sort of retrieval practice, like 'what was the key idea there?' And back to what I find interesting is that researchers earlier were sort of treating it as an artefact. They didn't think about it as something that actually promotes learning. It used to be viewed only as a way of assessing whether or not somebody has some type of intended learning outcome. And then they started to see that, when you were testing something on a regular basis, that people who encountered that were retaining the information and learning better.

So that was quite fascinating to me. I'm not sure how interesting it is to people outside of Cognitive Psych, but the fact that it was sort of treated as an anomaly before and now it's like an actual object or phenomenon of interest and it has a quite a robust effect. That's kind of fun to look at from a science standpoint because it's like it was hiding in plain view, we didn't know it was happening. So that's why I

think science is fun, because there's some things out there that you wouldn't think to do, or you wouldn't think about, and then you recast it or reframe it like, okay, that makes sense now, it's being demonstrated now as quite a powerful tool for learning.

Nina: That's really interesting, and Matt, I just want to say thank you so much for joining us this afternoon here in Auckland, or New Zealand, and this evening for you in the US. It's been really interesting to pick your brain and to hear your thoughts on this, and I think it's a real loss for New Zealand having you go back to the US, and I think we really miss having someone who's really focused on the science of learning in our university system here. But thank you so much for taking the time. It's been really interesting and you raised a lot of fantastic ideas, and I think also a lot of tangible things that the teachers listening in, and who will ultimately listen to this as well, will be able to hopefully take back and utilise in their own practice. And for everyone who has joined us this afternoon online, thank you so much and thank you for those of you who have asked questions. And just to note that we do have some resources available on our website that focus on a number of the things that we have been talking about this afternoon, so we hope that you will follow up with those, and they will provide you with some more ideas about how you can incorporate the science of learning into your teaching practice. So Matt, thank you so much.

Matt: Thank you Nina, it's been a pleasure.

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PREPARED FOR THE EDUCATION HUB BY



Professor Matthew McCrudden

Matthew is an Associate Professor at Penn State University. His research focuses on human learning and cognition and in particular how texts, task design and learner characteristics influence cognitive processes during reading and the products reading.