# Transcript

**Dr Judy Willis on the neuroscience of learning and implications for teaching**

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Introduction:

You’re listening to the Victorian Academy of Teaching and Leadership podcast where we showcase conversations with some of the world’s biggest thought leaders in education. We also bring you the thoughts and reflections of teachers and school leaders from across Victoria.

Lorena Pellone:

Hi everyone. My name's Lorena Pellone, and I'm here with my colleague Frances Braithwaite. We're master teachers in the Teaching Excellence Program at the Academy. Today we are so lucky to be joined by the internationally renowned thought leader, Dr. Judy Willis, where we're going to be speaking about the neuroscience of learning and the implications for teaching. Judy, welcome back to Australia and thank you for joining us.

Judy Willis:

Ah, thank you, Lorena and Frances. It's a pleasure to be with you again now that we've spent some time in workshops together.

Lorena Pellone:

So, Judy, you've been invited by the Victorian Academy of Teaching and Leadership to facilitate some professional learning in improving outcomes for all of our students, and working with our exceptional teachers here in the Teaching Excellence Program. Why is this work important for you?

Judy Willis:

When I work with any teachers, it's important because it links to why I went from neurology to teaching. But I feel that I have information that can facilitate teaching in other situations because of my background in neurology. To have teachers here that are this eager, this passionate, and in a program that is so well-designed, that their time is used profoundly efficiently in terms of what they're getting, the amount of time at each different process, the variety, and yet the sustained presence. So the faculty and the master teachers make this extra meaningfully important to me.

Frances Braithwaite:

Thank you, Judy. You've had such an incredible career. You had 15 years where you worked as a neurologist and then 10 years as a classroom teacher. On top of that, you have written seven books and you have over 200 published articles on applying neuroscience learning and research. Tell us about your journey.

Judy Willis:

Sure. Thank you for the question. I went to medical school, became a neurologist, practiced neurology for 15 years. During that time, there were more patients being referred to me by teachers for behavior issues that they thought might be neurologic in cause. I would only be seeing people who were presumed to have a neurologic condition such as petit mal epilepsy or damage to the attention centers of their brain or Tourette syndrome, which is an involuntary calling out.

So teachers would refer these kids, and the volume of the referrals really jumped in a two to three-year period. I found out by going to the classrooms what was happening, because there was no increase in the number of kids who had these conditions. But talking to the teachers, observing their classrooms, I saw the teaching had changed. The focus was on teach to the test. They were high-stakes standardized tests and requirements.

So despite their inclinations and creativity, teachers were being pretty much forced to focus on things that had to be memorized. From my neurology experience, memory was something that I knew well. So I thought, "Oh, if I could only tell teachers how this system works," but then I realized why should they listen to me? Yeah, I'm a neurologist, but they're teachers. They're professionals.

So I stopped my practice, went back to school so I could be a professional. Got my credential and master's in education. Then for the next 10 years, first in primary then secondary school, applied the strategies that I thought correlated with the neuroscience to my students. As things would go as I hoped, I'd write articles, and then books about it.

 Lorena Pellone:

Wow. Judy, that's so interesting. Something that you say really resonates with me in students and their attentions, and you're speaking about disorders with attention, parts of their brains. But something that I've heard through my experience with the COVID lockdowns, a lot of the teachers are coming back from those remote learning experiences and noticing that students' attention seems to have reduced due to an increase in the number of distractions that students are having. Is this possible? Can your attention reduce and how can teachers deal with such an issue?

Judy Willis:

Yeah. Just like with any skill that the brain has, and neuroplasticity, the more something is used, the more the circuit fires, the stronger it wires. When there's not use of the growing executive functions that pay attention, top-down attention focus, when they're not used for a period of time, the brain fills in the spaces, and there is more fidgeting and more distractibility. This is during the Zoom.

Since there wasn't that growth of these executive functions during these vital years, the school years when they're most responsive to being activated and used, then they return to school with less skill than they had coming in in terms of attention focus. Suddenly the appeal of being less physically squirmy in a classroom and less able to just get up and do something else, it's a big demand when you haven't had to do that for a few years, whether you're in first grade or whether you're in high school. Definitely a challenge when they came back for the teachers and the students.

Frances Braithwaite:

Yes, Judy. You've used the word neuroplasticity there. In Australian education, we have a lot of buzzwords, especially around the neurosciences, and sometimes we get caught up in the noise and we go along with the flow as teachers and don't really understand what the words mean. So would you mind elaborating on what neuroplasticity means for us?

Judy Willis:

Great, great question, Frances. Yes, neuroplasticity is a buzzword and is something that educators should know well what it means because it means a lot to students, because it has to do with the limitless potential of the brain.

Neuroplasticity refers to what holds information. Information is held, little bits of it, in neurons, but one neuron only holds a tiny little piece of the information. What makes a memory are connections from one neuron to the next. It's those connections, those dendrites and axons and synapses, that every time they're used, every time that circuit, that skill, that knowledge, that memory is activated, electricity flows through the circuit, and that firing is the stimulus for the brain to make those circuits stronger, lay down more myelin, more dendrites.

So that's the increased wiring. The more wiring you get, it means the memory or the skill can be retrieved more accurately, more rapidly, and retained longer rather than that summer slide forgotten over the summer. If it's strong enough, it's almost permanent, like riding a bicycle.

 Lorena Pellone:

Thanks, Judy. It really resonates with me. Something that a lot of Victorian schools are implementing is around retrieval practice, and that's around having targeted moments in your classroom where you'll get the students to purposely retrieve what they have been learning. I think it is based on that neuroscience background. But I notice that sometimes with the students, because this becomes maybe a repetitive part of practice, maybe they lose that motivation within it to retrieve on purpose, and particularly doing that at home and everything like that.

I know that a big part of your work is around motivating students, getting them curious about learning. Can you talk to us a little bit more about that?

Judy Willis:

Okay. I feel that the brain wants to learn. It wants to be better for survival and for pleasure. That's pretty much how the brain is programmed, for survival, pleasure, and patterns. So when we lead the brain to believe that those are in its future, of that motivates ... When we talk about motivation and the brain and behavior, we're talking about the brain actually investing the energy and effort.

So what we've found with neuroimaging scanning is that the increase in motivation that we're looking for has a lot to do with lowering the stress and increasing the brain's expectation of pleasure. So we can work from both angles, but the stressors that block motivated learning include frustration and boredom. The components that promote motivated learning have to do with the release of a neurochemical dopamine, which sustains motivation, pleasure, attention, memory, and perseverance.

Frances Braithwaite:

As a teacher, Judy, do you have some examples of, firstly, how we can reduce stress in our students and how we can combat that in the classroom? What are some ways that we can help to build those dopamine releases in our students to keep them motivated?

Judy Willis:

Okay. Since the biggest in-classroom causes of that stress are frustration and boredom. We know they are coming in with stress from many external factors, but internal in the classroom, the studies show that frustration from failure to achieve a goal despite repeatedly trying to, or from the brain, seeing something and believing it's too hard, it's unachievable.

The boredom which we see causing stress is associated especially with information where they've already mastered it. It's too easy. So we have the whole Goldilocks zone. If it's too hard, it's stress. If it's too easy, the boring is stress.

The other thing that is a high cause of the stress that blocks learning is failure to recognize what the learning will do for the individual. I mean the brain wants to learn if it knows it can get some of this dopamine reward, but if it doesn't see a desirable goal and if it doesn't see an achievable challenge, it doesn't want to do it.

 Lorena Pellone:

Yeah, that's so interesting. We have these high-impact teaching strategies that teachers want to implement, and the basis is a lot of HAD-IS research and meta-analysis. One of the high-impact teaching strategies is learning goals and setting meaningful goals for the students. But as you say before, unless they see the goal as meaningful, they may not buy into it. So how can we get our students to really buy into these goals and want to learn what we have to teach?

Judy Willis:

Right, right, Lorena, because it's true, if we say the goal of this is so you could take the class next year, or the goal of memorizing your multiplication table is so that you can do algebra, there's not that much buy-in, especially if it hasn't been successful in the past. That's not personally relevant to an adolescent or child brain, which is really programmed for the here, me, and now.

So it's great the teacher needs to have goals, know where they want things to go, but it's very important for the student to have a goal at least in parallel to the teachers. That can be made very explicit to students. "Okay. In this unit, you will master the vocabulary words, the translation, and the past and present tense in Spanish. That's what you'll be learning in this unit." However, why should you learn it? You're going to know it at the end of the unit, but what's going to make you want to?

If you were the teacher, what would you tell yourself? Why do you want to know? Then supplying a menu of things, including maybe one could be a menu that's in one language and they'd want to translate it into the other, or if your goal could be an essential question that's of interest to the student. Why do we have different languages when now that we have computers? It's almost like science fiction. We don't really need to translate. What's the good of it?

Or here's this video. You're going to watch a video in Spanish, no translation. It's a comic routine. A comedian is telling jokes. You'll hear laughter in the track, but you won't know what's funny. Well, by the end of the unit, if we build your skill, if you build your skill and work in groups, you'll start laughing at the funny parts, too. So those are parallel goals that sustain, along with authentic performance tasks, which the example would also be that video of humor.

 Lorena Pellone:

Yeah, I mean that sounds so exciting, that element of student choice and making decisions about their learning. It's hard for teachers. We're so busy, so time-poor. Can you give us any hints or tips about how to provide this level of choice for the students, but that's not totally time-consuming, if you catch my drift?

Judy Willis:

Yeah. A great way to provide choice without you having to think of all these choices is to put it on them. They could start in small groups or individually, think-pair-share. But that question, why should you learn this? Let's flip through the chapter, or I'll show you or read to you my curriculum guide for this unit. Let's take some time ...

Try to sell it to yourself or try to sell it to your partner. What's good of learning this? Okay, you see what you're going to learn. You see that subheading. In your group, pretend you're a salesman. Why should someone buy that topic? So we don't have to do as much of the goal motivation or finding out what their interests are. They will discuss it among themselves and share it with the class. "Yeah, I want to know that, too."

Frances Braithwaite:

I really love that idea of the front loading that you're speaking about, giving them the vocabulary. As a primary school teacher, we sometimes forget how important it is to give the students the goals, because it really does drive them. As Lorena said, when we're so caught up with how busy we are, that's something that we sometimes do forget, but it is so important.

As a teacher, though, one thing that I think we do struggle with is building that intrinsic motivation at times. I know that you talk a lot about the video game model in building that motivation. I'd really love to hear your thoughts on that and how that can build that motivation.

Judy Willis:

Great. Okay. The thing I mentioned earlier, the brain doesn't want to put in effort when it's perceiving stress, and there's a blockade of flow through this emotional filter. So we reduce that by making more evidence of that it won't be boring, it won't be frustrating, that they will get to work in a Goldilocks zone. I describe that as achievable challenge.

The video game uses achievable challenge, which releases dopamine, that makes video games want to keep playing. So as I described this model, just to be clear, it's not because videos are the only way to teach or even a substitute, don't need to be used in the class. This research was to find out what drives a dedicated video gamer to keep being motivated even though they keep making mistakes and they're not making progress to the next level. They can make up to 80% of errors in their predictions. Should they aim this way? Should the code be in this order?

So 80%, when they're playing the video game of their choices, their predictions can be incorrect and they will continue to play. They'll persevere. And better than that, they'll even learn from the feedback. They'll learn from their errors.

Now we don't get that in the classroom. I certainly am not somebody who after only achieving a 20% on success, despite repeated trials, my brain wouldn't and I wouldn't personally feel ... I wouldn't do that anymore.

So the system that is invoked in the video game model has to do with the release of a brain chemical called dopamine. There's a sac of dopamine deep in the brain, near the emotional limbic system. We know things that release the dopamine. Remember, the brain seeks pleasure and it seeks patterns. To get it to believe it's going to get pleasure, we can release dopamine. When it gets pleasure, it even releases more.

So what's the big deal about the dopamine? Well, the things we want to know is what happens to the brain when this dopamine is released and bathes the brain? And also, not only what happens, because it's good stuff, what are the things that cause it to happen? So what we see when there's this surge of dopamine released from the sac deep in the brain, we see a cluster. We see a person experiencing increased pleasure and satisfaction, but also increased motivation, perseverance, and memory, motivated learning.

So what causes a dopamine to be released? Because we'd like all of our students to be in that state and that persevering and that motivation. So the things that have been found strongly associated with the surge of dopamine are things that no doubt you as educators already do, but maybe there are some you don't already do.

The list is not in order, but listening to music, movement, interacting with peers, being told to or read to a story or an anecdote, the movement, if I didn't say it. Making predictions and achieving challenges are two big releases of dopamine.

So knowing what releases a dopamine, knowing what we get when the dopamine is released, this motivation, this satisfaction, this pleasure, the video game matches the two. They get to make predictions at each level, choices, without mistake, fear, the video game's not going to scold them for making a mistake, or without having to be at the same speed as the class because it's individual.

So we want to look for that in a classroom, how we can let learners achieve mastery at their own appropriate pace, not the whole class at once, where some people will be bored and some people will be frustrated. The other part of the video game playing is that there's goals en route to the final goal. They can name the goal, they have to be able to identify the goal of the game. It's usually fantasy, saving the earth from a big meteor.

But en route to the goal, just like in the classroom, they need to know how they're doing en route to a final project, paper, or test. The video game, if it has 10 levels, when they master a task at level one, it may take them a lot of tries, it may take them one or two. But at the time they have mastery, they're promoted to the next level. They have evident feedback that they have made progress to the goal because avatars change, the background changes, the music changes, and most important to the brain, the task changes.

When the brain recognizes that the task has two characteristics, it's a challenge. It can't be the same as level one, which I already mastered. The brain will say, "No, I'm not going to get dopamine." The brain will release the dopamine with both elements, achievable and challenged. So it needs to recognize there's a challenge and see how it's achievable.

It's achievable in the video game because you get a lot of practice as much as you want with making predictions and getting feedback. In the classroom, it's achievable when students know they have scaffolding or enrichment, and when they have different pathways to access the mastery with the understanding clear from the teacher that they all will achieve mastery by the end of the unit.

 Lorena Pellone:

Wow, Judy, that's so interesting. I'm imagining my students, and I can picture them ... I come from a secondary school. I can picture them getting really excited with each other, high-fiving each other, and I'm thinking about that in terms of the dopamine release. I have a question around the students who might've ... They seem to have already given up before even trying, not being open to learning at all. The way I noticed that is through them acting out or maybe wanting to go to the bathroom a lot, saying, "I can't do this." I'm a science teacher so, "I can't do science. I'm not a science student." So how do I even get them started and into that video game model if they don't seem receptive?

Judy Willis:

Yeah, that's important, because the video game has the buy-in, first of all. They know what their goal is, and it can be fantasy and they want it. But so we certainly want clear goals for their buy-in. But also not just the goal, but the evidence to the student, how they're going to be assessed and how they're going to be able to reach the goal.

I mentioned that they need different roots to mastery to achieve the goal, but they also need to know why they should care, that personal relevance. So knowing what each student is passionate about, what appeals to them. And we pass notes from year to year. A teacher getting the new class might get their test scores, or problems with the student, but we rarely pass along motivators, so, "This kid is passionate about navigation."

So when you know what your students are passionate about, incorporating that into the buy-in, into the introductory goal of what they're about to learn, that will continue and sustain their motivation as they enter it.

For some students, for example, my students in maths, who, in algebra, they came and say, "I can never do it. I can't," and they have had seven years of failures, of being told they can't, or the parents who say, "Oh, math isn't that important. Look what I can do. I was never good in math." So there's a lot of problems surrounding that.

One year, the students in my group ... Because they were level groups, levels one, two, three. One year, the lower level would not even try. I did all of my things I could to motivate it ... And it was algebra. They had to know their multiplication tables, and they didn't. I gave them calculators. Things weren't working.

So I said they need to recognize that their effort toward a goal makes progress. The reason they need to know that, not so they could give a report. Yes, I put in goal, I put in effort, I got better. It's so their dopamine reward system says, "Okay. Doing this made me feel good." So being aware of progress made me feel good. So I make that very concrete.

Instead of teaching maths, I had them go out in the field, gave small groups basketballs, there were several basketball hoops, and had them spend the maths period shooting shots, shooting foul shots. They were told, "This isn't a trick. The only thing you're going to have to do at the end in terms of maths is the last five minutes, we're going to see ... With your group, you'll measure how many you get in a minute, and then we're going to come in the classroom and plot that on your individual graph. It's called an effort to progress graph, which will basically be how many minutes total I've practiced the foul shots over this week and each day how many I got in over that minute at the end."

So by the end of the week, they all had evidence that their effort, their practice resulted in progress. So it was important to have them discuss it. So what it's called, an effort to progress graph, but what did you recognize? They need to verbalize and recognize that.

So let's apply that to maths, because you're going to be successful. Ask the kids who were in this class last year how they felt at the beginning. You can trust me on this. If you don't, if I'm not complying with what your expectations were, tell me. I want you to give me your report card.

So with that evidence, that effort to goal progress in some area was successful. The brain had that success because dopamine was released, because the challenge was achieved. It was shooting foul shots, but now they get to apply that to maths.

 Lorena Pellone:

I love that, Judy, effort to progress graph.

Frances Braithwaite:

Oh, it sounds fantastic. Something that's jumping out so strongly for me is that level of differentiation that you have, yet they're all working on the same task. You were talking about when you did the three separate groups, that sometimes that lower group just wouldn't engage. I feel that having that whole class challenge to task would just motivate students and have them working at their own level, but it also makes them feel like they're a big part of the bigger picture.

I think that that's something that as a teacher, we sometimes struggle with that level of differentiation. But this notion of bringing in the provocations, of bringing in this Goldilocks model, it just makes me really excited to go back and try this with students. So thank you so much for sharing that.

Judy Willis:

Good. Yeah, providing scaffolding so that the whole class can progress to the cool things, whether it's a project or whether it's being able to use a graphing calculator, whatever the thing that is appealing. Younger kids, there are manipulatives they get at the beginning and they get to play with, but they can see pictures of what students do when they were there last year.

So when they have that motivation and know that they can achieve it at their own level and get feedback ongoing that they're making progress, then the whole class is doing it. But more scaffolding is being provided to some students.

They may get the calculator while we're progressing to equations in algebra. So they don't have to automatically know their multiplication, but they're able to progress with the rest of the class in formulas.

 Lorena Pellone:

Judy, I have a question around your shift from neurology into teaching. Something that we do in the teaching excellence program is we support our teachers to develop practitioner inquiry. We give them structures to be able to research into their own practice and really applying theory to practice.

Just out of curiosity, how was that for you? Because you had all this theory coming into teaching. Was it an easy theory to practice, "Oh, this is what the research says. This is what I'm going to do, and then I get the results," or was it harder than that?

Judy Willis:

It's a very good question to consider. What I did when I brought neuroscience into my teaching practices, the way teachers in this program have the opportunity to be in the field, researchers in their own classroom to apply theory to practice. Indeed, that's what I was able to do in neurology.

But as teachers clearly are finding in this program, they're entering, even beginning teaching with a level of expertise in different things. It might be in art, it might be in music, it might be in sports, but they have an expertise that they know what motivated them to persevere and become successful in it and passionate about it and letting students see that and using, "Hey, what made me keep going? It wasn't always easy to play this musical instrument."

So taking one's background knowledge, "Okay, this is what worked for me, this is what works in the research," and in my case, knowing what worked for my patients and in the research. So applying that was plenty of trial and error. There was no cookbook, and there shouldn't be. I mean there's too many direct, "Let's do this, you get this." Teachers are creative and passionate about bringing their own knowledge and expertise and experience into the classroom.

So I failed as many times as I succeeded, or more, but I wouldn't wait. Just like with students, I wouldn't wait until the end of a unit to self-assess. I would know what my daily goals were, my long-term goals were, and know what I was going to try applying, and, as quickly as I could, know what feedback, "Oh, they are talking less. They're talking more. They're asking good questions. They're asking more of the repetitive questions, like how many pages does it have to be."

So I knew what I would see, that reflected success of strategy. When I saw that, my dopamine went up and I'd continue to apply and try new strategies. If I saw it wasn't working and I saw the students acting out or zoning out, I had a fallback, some other, and we always do, as teachers, have fallbacks.

Frances Braithwaite:

I love that you were on your own inquiry cycle and that it was continuous, and you continue to ask yourself questions as well. I think as teachers, we sometimes have that fear of failure. So that idea of trial and error is fantastic. But as teachers, we do get scared sometimes to have a go and get into that research zone. Do you have any advice for teachers that are a little bit tentative about playing within their classroom?

Judy Willis:

I think that the rules of the video game model work for teachers, where mistakes, failure are learning opportunities, which means a teacher has to be comfortable making a mistake, that it's not going to be reflected in how the students feel about them or the parents or the grades. That making mistakes en route to a goal is natural. If you're not making mistakes, it means you already know it. If you already know it, you're not learning.

So if you're not making mistakes, you're not learning. You're not going from the unknown to the known. So recognizing that, knowing that it's okay and knowing what you have as a backup plan will sustain students as well as teachers.

 Lorena Pellone:

Yeah, I think that's such an important point. In the TEP, we also say ... Or the Teaching Excellence Program, we also say undertaking a genuine inquiry into your practice rather than a pseudo-inquiry, and getting out of your comfort zone and actually taking risks and modeling this to your students, showing that you're a learner too and that you are also taking risks in your classroom.

Just out of curiosity, Judy, what's one of your favorite memories from you in the classroom? Maybe a student who left a particular impact on you, changed the way you saw teaching, or had a significant impact on you.

Judy Willis:

I think I'm going to answer that by what strategy I came up with that engaged multiple students in areas that really were the hardest for me to teach. When I was teaching algebra, or even before that, in elementary school maths, there were things that students, their least liked in maths, decimal to percent conversion and ... That was a big one, and metric systems. So those things were hard, metric to standard.

So when I was teaching in the seventh grade, it was a private school, it's easier to ask forgiveness than permission. So I said, "Who would like to drink some wine in class?" Oh yeah, sure. If nothing else, the bragging rights. So we're going to call this the grapes of math. Every group got a hygrometer, which measures specific gravity, which shows ... And they got organic grape juice. So fermentation, as I explained to them, is just converting sugar, which is in this grape juice, into alcohol and carbon dioxide.

How do you know ... What do you want to know now? You're going to have this ... It's going to go on for a while. A few weeks. What do you want to know? Same question. "When will it be wine?" Well, that's what you have the tools to figure out.

So by looking at measuring this specific gravity of their grape juice each day, they could plot a graph, where it was going, how long it would take. It wasn't linear, so it was like a curve graph. Along the way, they needed to use decimals, percent, standard scientific notation.

I said, "Oh, and while we're doing this, you're also going to have a vineyard. Pick a grape variety you like. With your grape variety, they're all different sizes, how many do you need for a bottle of wine? It won't be the same for all of you. How many can you get out of your hectare, more metric or standard field of vineyard grapes?" And they loved it.

At the end, we used room mold for the fermenting agent. So they just had open cups of grape juice. At the end, I wanted to comply with my promise, but I knew the yuck factor would intervene. They only got a paper towel from a dispenser to filter their gross mold off of their wine, and they got it. They got to pour it into little glasses that were not see-through, so they could pretend they drank it, because it was disgusting. But they brought it to their lips, looked around, and gave high-fives and learned the grapes of math.

Frances Braithwaite:

That is amazing and so engaging. I love how much of the math and the technique and skill that you brought into that one little activity, and so much learning and engagement happened. Thank you so much for sharing that story, Judy.

Judy Willis:

You're welcome. And I didn't get in trouble.

Frances Braithwaite:

Oh, good. I didn't have to ask [inaudible 00:35:28].

Judy Willis:

It was actually in the newspaper in the town, city newspaper. It was applauded.

Frances Braithwaite:

Oh, lovely.

Judy Willis:

The kids loved it.

Frances Braithwaite:

Thank you so much, Judy, and thank you so much for your insights today. We have just one last question for you today. If there was one wish that you had for every student as they go through their educational journey, what would that wish be?

Judy Willis:

To finish each day, if not each class, feeling success.

Lorena Pellone:

Thank you, Judy. I do wish I could be one of your students. It just seems like you take the utmost care for each and every one of your students and the teachers that you're working with. It's been an absolute pleasure to speak with you today. Thank you for your time.

Judy Willis:

You are both delightful interviewers. Thank you for inviting me.

Outro:

We hope you enjoyed this Academy podcast episode. You can find out more about our upcoming professional learning opportunities at academy.vic.gov.au and follow us on social media to stay up to date.