



## **Practice Makes Progress:**

# The Relationship Between Engagement and Exam Results.

Prepared in Partnership with McGraw-Hill and Professor van der Rhee, Nyenrode Business University.



## Making the case for practice.



## A paper looking at the impact of McGraw-Hill's Connect on student success.

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\* In this study, a 'unit' of practice is calculated based on students' engagement with online learning materials. For a more detailed explanation of Connect's Online Engagement Indicator (OEI) see page 4.

<sup>+</sup> In this study, students on average scored 0.27 points higher in their exam grade (out of 10) for each point of OEI over 4.

Practice makes perfect is one of the world's oldest truisms; however, research into cognitive science has shown us that there is more to expertise than mere repetition.

Anders Ericsson, Professor of Psychology at Florida State University, is known to many as the man who told us it takes 10,000 hours of practice to master anything. Yet he is at pains to highlight the enormous difference between the accumulation of experience, which he calls 'naïve practice', and the more cognitive 'deliberate practice'. His seminal research into memory and learning identified key features of practice that make it 'deliberate', and which are required for it to be effective. In brief: the learner must have a specific goal; they must carve out time to give it undistracted focus; they should receive timely feedback; and they should be pushing out of their comfort zone, operating just at the boundary of what they can and cannot do.

Added to this is the notion of 'retrieval practice', a strategy championed by another leading cognitive scientist, Dr. Pooja K Agrawal, and her team at the University of Washington in St. Louis. The theory goes that learning is improved by the regular and conscious retrieval of information which helps commit knowledge to long-term memory. Thus, while traditional revision methods such as re-reading textbooks, highlighting information and reviewing notes may have positive short-term results, research shows that the effects are short-lived; consolidation is better achieved through tests or quizzes that force learners to search their memory banks, with 'opportunities for recall' drip-fed over time.

While students might balk at the idea of a test or quiz as a form of revision in itself, worrying that they might 'fail', it is actually a positive, because challenge and struggle, or 'desirable difficulty' as Robert Bjork (1994) calls it, improve our memory and learning. Making mistakes and receiving feedback is part of effective practice. Put slightly differently by Ausubel et al. (1978): "[consolidation] is achieved through

There's an enormous difference between accumulation of experience and deliberate practice.



confirmation, correction, clarification, differential practice, and review in the course of repeated exposure, with feedback, to learning material."

Both the theories of 'deliberate practice' and 'retrieval practice' align very well with Bloom's taxonomies. Practice is the conduit between levels of learning objectives – whether it is targeted mental practice to help students remember and understand, or practice in application and performance that turns learned responses into habit, it is only through good quality practice that a student develops proficiency, fluency and the ability to create, adapt or originate with what they know.

In an ideal world, therefore, students would be using their study time outside of the classroom to practice regularly, spiraling back to specific concepts and skills, understanding what they know and don't know, making mistakes and receiving feedback over a long period of time before an exam. Yet the reality is that learning in Higher Education is not always set up to work this way.

The challenge facing educators, therefore, is to find ways to embed deliberate and retrieval practice within courses, not simply as an adjunct, but as a core part of the teaching and learning process, breaking down cultural resistance along the way: creating the right set-up, and convincing students of the expanded potential for learning that stems from this continual effort. In this study, we see how Professor van der Rhee has managed to achieve this with his students at the University of Nyenrode in the Netherlands.

## The empirical evidence deliberate practice has on outcome at Nyenrode Business University.

rofessor Bo van der Rhee is Professor of Operations Management at the Center for Marketing and Supply Chain Management at the Nyenrode Business University, a leading university in the Netherlands. He teaches courses in both the Full-Time and Part-Time Master of Science programs, which have been selected as the Best Business Master's in The Netherlands numerous times. In his own words, he is "quantitatively inclined", which is why he is able to give us not only anecdotal evidence of the effect of student practice on exam success in his business statistics class but also rigorous analysis of data gleaned over three years. As a user of McGraw-Hill's Connect homework and learning management platform for over five years, Professor van der Rhee has successfully used the analytics provided by the software to explore the relationship between students' OEI score (Online Engagement Indicator) and their ultimate grade on the course exam. The OEI score is calculated via an algorithm that looks at factors such as the number of times a student logs in to Connect and the number of attempts they make at getting a question right - ergo frequency of engagement combined with quality of engagement. This score gives a reasonable proxy for deliberate practice.

As a long-term user of Connect, Professor van der Rhee has now settled into a pattern of using Connect with his students and, consequently, has three years' worth of consistent, reliable data to review in conjunction with students' final exam results in order to prove or disprove a correlation between deliberate practice and exam success. Taking results from both full-time and part-time students gives Bo a total of six data sets, looking at over 450 students on the standalone statistics course for which Connect is the only recommended homework practice tool.

Professor van der Rhee has analysed this data, split into full-time and part-time students, and has been using his findings in innovative ways to feed back into teaching and learning, as we will discuss later. However, for the purposes of this paper, the McGraw-Hill Research and Development team has also carried out their own, independent analysis on the data for verification.

Using linear multiple regression and logistic regression analysis across the dataset of full-time and part-time students for the first two years, the McGraw-Hill team looked at whether age, gender and OEI could predict pass or fail, and even course grade.

The results showed that age and gender are not statistically significant predictors of exam grades, but that OEI is. Simply put, the more time a student had spent engaged in quality practice in Connect, the better they tended to perform in the assessment.

"I'm looking at what's going to improve outcomes for the class as a whole and this research shows that **OEI** - i.e., practice - consistently has an impact on the grade."

Professor van der Rhee

A simple linear regression of Professor van der Rhee's data, blending together data from the full-time student data and the part-time student data, using OEI versus course grade, then showed that for a one-point increase in OEI, we would expect to see 0.27 increase in exam grade. With exams graded from one to ten, this means that roughly 4 points of additional online engagement equates to an entire point of exam grade. And with the threshold for a pass at 5.5, even a single point of additional engagement amounting to a quarter of a grade point - could be enough to tip the student over from a fail to a pass. See Figure 1.

### Figure 1: Scatter plot of OEI on Exam Grade for both full-time and part-time students with fitted linear regression line.



For a one-point increase in OEI, we would expect to see a 0.27 increase in exam grade.



Analysis of the logistical regression of OEI has further suggested that for a one-unit increase in OEI, we would expect to see a 31% increase in the odds of passing. The model was 68% accurate in predicting which students would fail and 60% accurate in predicting which students would pass.



While 60-70% accuracy means that the model isn't a surefire way of predicting success (some students will practice a lot but still fail, while others may not practice at all and still pass), the correlation is highly positive overall. The data (Figure 2) shows that with an OEI of 4 points, the probability of passing or failing is around 50%, while with 6 points, a student is twice as likely to pass as to fail, and for students

with an OEI of 8 or above the pass rate is around 90%. "Statistics always talk about averages and trends," says Professor van der Rhee, "there will always be outliers, but as a professor of large classes I'm looking at what's going to improve outcomes for the class as a whole and this research shows that OEI - i.e., practice - consistently has an impact on the grade."

#### Figure 2: Relationship between OEI and Probability of a Pass.



#### If a student's OEI is >4, then the student's probability of passing is >50%.

In Professor van der Rhee's own analysis of the data, he identifies that in some cohorts, factors such as country of origin and type of previous education (academic versus vocational) seemed to have a bearing on the probability of a student passing the exam – but in other cohorts, these trends were reversed or made no difference. The only consistent predictor of exam success throughout the six cohorts was online engagement.

What was evident, when the data was split, was that part-time students on average practice more in Connect (and therefore have higher OEI scores) than their counterparts in the full-time course yet achieve exam results that are broadly in-line. When all the data is merged - and if we adhere strictly to the simplified formula of more practice equals higher exam scores - we might expect to see the part-time students scoring higher than their full-time equivalents in the tests, yet this is not the case.

This can be explained, however, by the characteristics of those part-time students, who tend to be an older cohort - professionals returning to further their studies rather than recent bachelor graduates. As returning students, this cohort is often faced with the disadvantage of having been out of education for a while, with elements of their prior learning that they need to refresh. The part-time students are, therefore, coming from further back than the full-time students - they need to do more practise in order to achieve the same results as their full-time peers. So the fact that the two groups achieve broadly the same class average is a real reflection of the impact of the practice they have done.

Figure 3: Relationship between OEI and Odds of a Pass.



If a student's OEI is >6, then the student is twice as likely to pass than fail.

#### Table 1: Practice to progress ratio for full-time versus part-time students.

	Average grade with no practice (OEI = 1)	Average increase in grade for every 1 point increase in OEI	OEI average	Average expected grade for average OEI
Full-time students	5.53	0.28	3.46	6.22
Part-time students	4.77	0.32	5.21	6.12

The data shows that additional practice in Connect helps part-time students achieve similar outcomes to their full-time peers thus showing the significant impact practice has on success.





## Driving further engagement through data.

Professor van der Rhee uses this data in an innovative way to help boost his students' motivation. During his last session with his students, he shows them a set of data consisting of three explanatory variables and one variable that needs to be explained through a regression analysis. After students determine that two of the three explanatory variables have no impact, while the third one does, he asks his students to guess what data they worked with. Through questioning and guess work, students eventually realise that they are looking at exam grades of the previous cohort as the variable that needs to be explained. The two variables without impact are Age and Gender, and the one that does have an impact is the Online Engagement Indicator from Connect.

At this point, two things usually happen: 1) students realise that practicing in Connect has a real impact on their grade, and 2) students will ask questions such as: "What's my current OEI score? Have I done enough?" As natural as this is, in doing so, they are somewhat missing the point. Regular, repeated, deliberate practice until real understanding and fluency of application is achieved is the key - but it is difficult to say at what point that is reached for any individual student. Professor van der Rhee, therefore, declines to give individual students their score. "A student who knows they have not logged in often to Connect during the course now has a couple of weeks to remedy the situation ahead of the exam. While a student who has a high score should not be lured into complacency but should be continuing to study anyway. Not knowing exactly what constitutes a 'point' of OEI or how many points they have is significantly more motivating."

With an OEI of 4 points, the probability of passing or failing is around 50%, while with 6 points, a student is twice as likely to pass as to fail, and for students with an OEI of 8 or above, the pass rate is around 90%.



## Transformational change: putting practice at the heart of learning.

While this analysis shows a clear, empirical correlation between students' use of the Connect practice software and exam success, as discussed in the introduction we cannot simply equate practice in general with increased success. We know that the quality of the practice is of paramount importance. It is very difficult to unlearn something that we have repeatedly practiced incorrectly. For practice to be truly effective, therefore, it cannot be done in a vacuum: it has to incorporate that cycle of 'confirmation, correction, clarification, differential practice, and review' as described by Ausubel.

It was partially this which initially prompted Professor van der Rhee to look for an alternative to the traditional textbook-as-homework-tool model that had been the status quo at the business school for many years. Previously, homework would consist of a selection of practice questions from within the textbook. Basic answers could be found at the back of the book but with no clarification for students as to why their answer was wrong. Bo found himself receiving anywhere between 60 to 120 emails from students every week. Answering so many emails was a huge drain on his time and he felt there must be a better way. It was at that time that he came to discover McGraw-Hill's Connect.

In the early days, Bo used Connect alongside a traditional model of teaching. Class time was devoted to explaining theory, and a sample Connect question would be worked through together at the end to help students familiarise themselves with the platform's functionality and interface. The volume of emails he was receiving dropped and, in addition, he was able to see which areas students were most struggling with through Connect's reporting tools. It was a huge improvement, but students were still arriving in class with lots of questions (albeit better, higher-order ones). The feedback from students was that they were leaving class feeling like they had understood the theory but by the time they logged on to the practice questions they once again struggled, and they found themselves overly relying on the Connect help functionality. They started asking for more practice within the class.



## How does Connect support deliberate practice?

Online practice in Connect helps students fulfill the criteria of Ericcson's model of deliberate practice in the following ways:

- Homework tasks are set up by the course leader to work on specific learning goals.
- The adaptive technology in Connect will filter questions to students based on their individual need and understanding to keep them moving along at the border of their comfort zone.
- Students receive immediate feedback from within the software when they get a question wrong, with in-system help available to help them understand their mistakes.

#### How does Connect support retrieval practice?

- Practice in Connect takes the form of quizzes and tests, giving students ample opportunities to 'retrieve' what they have learned.
- The system will offer help when students have answered incorrectly, and then offer another opportunity to answer the question, facilitating consolidation.
- Course leaders can design homework to repeat and interleave learning objectives as research shows that retrieval is better when opportunities are spaced out and mixed up with closely related topics.

### Flipping the classroom.

A s a result, in the 2014-2015 academic year, Professor van der Rhee transformed the way he ran his courses altogether by adopting a 'flipped classroom' approach. Now students pre-learn the theory before they come to class via a series of video lectures he created. Engagement with these is mandatory, while practice in Connect is not. However, Bo is changing this so that, moving forward, his students will be graded for their preparation efforts in Connect as well. Structuring his classes like this frees up time for students to work individually or in small groups on

Algorithmic questions in Connect present the same problem, but with different numeric values, to each student, so the "correct" answer on the board is not the correct answer for every student – the method to solve the problem is of course the same.

algorithmic problems\* within Connect. The Professor will lead them through sample problems on the board, while groups will work on different variations of the problem. Rather than remaining at the front of the room, Bo can wander around from group to group offering support and personalised guidance on approaches to problems. It is during that time that, Bo explains, he will frequently receive 'high-fives' from his students - a potent indication of their engagement with his teaching method.

Homework takes the form of additional independent practice in SmartBook, part of Connect, which offers students their own personalised adaptive learning experience. This homework is completely voluntary for now and, while it is actively encouraged through message prompts, it doesn't count towards the final grade in the same way that the video lessons do. However, what the Professor's research shows us is that it very much counts unofficially. How much students do in Connect of their own volition matters: on average, students who don't practice in Connect don't pass, but as the OEI goes up, their expected grade, as well as the probability that they will pass the course, goes up. "Independent practice in Connect isn't officially part of the course grade but the research shows that it actually contributes a great deal."

By flipping the classroom, Professor van der Rhee has succeeded in putting deliberate practice at the very centre of the course: first, by giving students the time to practice and embed the theory within the classroom, where they are able to get immediate feedback from, and interact with, the expert (the teacher) and their peers, and second, by giving them opportunities, through Connect, to engage in quality practice beyond the classroom as often as they are prepared to do so. This is the dividing line between those who are content to be 'just good enough' and those who are striving for mastery. It requires commitment and planning. Under Plant et al.'s (2005) definition of deliberate practice, it requires: "high levels of concentration with few outside distractions" and being "not typically spontaneous but carefully scheduled" - on their own. If Professor van der Rhee's study shows anything, it is that practice is a serious business and ought not to be viewed as a 'nice but non-essential extra' to the classroom-based activity.

Connect is a learning technology platform designed to improve student learning, enhance course experience for both students and instructors, and improve the efficiency of course management for instructors. Connect offers one destination for all course content, assignments and quiz banks, deep insights into student performance, recommendations for students on how to improve, and adaptive learning features that customize the student learning experience. Educators can build their own bespoke courses in Connect, drawing on pre-loaded reading, homework tasks and assessments from over 90 disciplines, and integrate Connect with other Learning Management systems.

As part of Connect, users have access to SmartBook®, an adaptive learning and reading tool. SmartBook highlights key topics for students to focus on, and provides links to additional material such as videos and slideshows, so they can deepen their understanding of the learning objectives.

### What's the conclusion?

While there is a growing body of research into the science of learning that shows the immense value of deliberate and retrieval practice to student outcomes, there remains a tendency in education to stick with what we know; for educators, this is the tried and tested method of lecturing from the front with slides and handouts, recommended reading, and periodically marked work with variable degrees of individual feedback. For students, this is cramming at revision time, relying on re-reading, and note-taking to refresh knowledge in the short term.

Though this has worked reasonably well for centuries, modern technology now affords the means to do things differently, in potentially superior ways. With instant social communication tools, multi-media learning platforms, adaptive technology, and 'big data' analytics, technology simply allows us to help more of our students do better. Technology allows us to look with fresh eyes at the way we do things and to break with the mould in ways that revolutionise learning if only we are brave enough.

Professor van der Rhee's work is a prime example of how the innovative use of technology can have a huge impact on not only student outcomes but on student satisfaction, and teacher workload. As we approach the third decade of the 21st century, this story is not a new or isolated one, and forward-thinking departments in Higher Education the world over have already begun to experiment with a 'new education' that draws on the best of technology with dramatic results. What is special, however, about this study, is that we are able to draw an empirical link between deliberate practice and exam success. This is interesting from a pedagogical point of view in its own right, but what is additionally interesting here is how this evidence





can be used to motivate students – to prove to them that homework practice is an essential part of learning and that the power to succeed is very much in their own hands. What they put in, in terms of quality practice, has an observable correlation to what they get back, in terms of results.

In Nyenrode, this transformation has been brought about by a teacher with a vision and, through Connect, the tools to help him make it a reality.

If you would like to speak to one of our consultants about how Connect and learning science could help support you, please visit mheducation.co.uk/contact-a-rep