Chapter 1
Changing Minds: Multitasking During Lectures

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Abstract This chapter takes a multidisciplinary approach to multitasking. Media multitasking has, consequently, become a frequent topic amongst academics yet some remarkable new research is revealing that we may not be taking into full account the changes to our students' ability to learn, given the changes to their brains. The risks of multitasking to student achievement have been well researched yet many of the positive related developments in neuroscience are less well known. This chapter reviews some of this research bringing together: information foraging theory; cognitive control; and confirmation bias as they relate to the multitasking Generation Z student in higher education. Some significant research findings are discussed, including using laptops and similar devices in the classroom. A small survey underpins these discussions at the end of the chapter, highlighting student perspectives on multitasking during lectures.

Keywords Multitasking · Cognition · Information foraging · Academic performance

1.1 Introduction

It is in our nature to do more than one thing at a time: to multitask. Multitasking feels good. Dopamine is released every time we turn to a new task (Strayer and Watson 2012). Our motivation to multitask is a natural human urge—we are foragers, and more recently in our technological history, information foragers (Pirolli and Card 1995).

Multitasking is defined as using two or more media concurrently. It is slightly different from task switching where one switches attention between two tasks. They are closely related, but for our purposes, we will define multitasking, sometimes referred to as media-multitasking, as involving at least one device that coincides with the "performance of two or more functionally independent tasks with each

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of the tasks having unique goals involving distinct stimuli (or stimulus attributes), mental transformation, and response outputs", (Sanbonmatsu et al. 2013).

Multitasking with various devices is also commonplace in university classrooms (Junco 2012). Three out of four students believe technology improves their educational experience and since 2015, 90% of students have both laptops and smartphones[1] (Statista 2017). Media device dependency, especially among 18 to 20-year-olds, shows 44% are compelled to access a device at least once every ten minutes (VitalSource/Wakefield 2015). These factors are profoundly impacting student focus, attention, distraction and consequently academic performance. Nonetheless, these factors are complex yet offer possible solutions that may require substantial shifts in thinking, both on the part of the student and the lecturer.

This chapter discusses why students are compelled to multitask particularly around information-intensive activities. The focus is on multitasking in the classroom of first-year university students but also attempts to understand the current multitasking debates including some problems involved in attention and distraction in the context of teaching computer science in higher education. This discussion then delves into a few of the recent studies in neuroscience to better understand the complex relationships that underpin multitasking. To summarise, this chapter seeks to expand the discussion on multitasking through the lens of a multidisciplinary approach to the topic. Through a small pilot survey at the end of the chapter, we gather data drawn from a group of first- year computer science students as first-hand evidence of the state of the debate.

1.2 Information Foraging Theory and Multitasking Check Para Numbering Here

We have to ask why humans have a compulsion to multitask? What is driving this urge? One theory stands out and helps make sense of this innate drive to multitask where we are in pursuit of information-intensive tasks. Understanding this problem from a behavioural position is vital given the context of teaching and learning in the classroom and given the increasingly sophisticated social and technological tools at the students' disposal. Information foraging theory (IFT) was developed at the Palo Alto Research Center (PARC), to develop project models for the User Interface Research Area, this theory provided 'novel' information visualisation for searching and browsing (Pirolli and Card 1995, p.50). IFT goes some way to explaining our drive as humans to accumulate information. This theory is particularly important due to the level of information available to students and their drive to multitask and task switch. The IFT research team primarily used participants from the areas of business intelligence and MBA students. The team quickly realised the depth and variety of phenomena that needed to be dealt with when handling massive volumes of information, deadline constraints and complex search decisions in the context of uncertainty.

[1] Between 2011 and 2017 smartphone use doubled from 21.6 to 44.9 million in the United Kingdom.

Early on they realised they were dealing with something different from the standard human–computer interaction tasks originating from cognitive engineering models of the 1990s. Comparatively, they recognised the behaviours of people seeking information was largely determined or shaped by the architecture of that content, also referred to as the *information environment*. It was clear the participants' behaviour was only minimally shaped by the users' knowledge of the user interface. What is interesting here is how this model maps onto the classroom and the context of learning since Pirolli also found behaviour tended to be dominated by uncertainty and continual evaluation–a common attribute when learning a new skill or concept. Information foraging theory (IFT) was theoretically developed from optimal foraging theory (OFT) (Krebs 1977). OFT is largely a theory developed from predictive models of decision rules used by predators and originating from the theory of natural selection focussed on maximising food intake during foraging (MacArthur and Pianka 1966). Generally, IFT theory asserts that we have evolved to use information to solve problems that can pose a threat to us and our environment. Rather than forage for the food, we now forage for information. The theory goes on to explain that we have adapted cognitive solutions for survival. The technological need for survival forms a basis for human interaction with information technologies as demonstrated by the World Wide Web (Pirolli and Card 1995, p. 51). The earliest discussions about multitasking borrowed heavily from the biological sciences in this paper. The book that followed twelve years later, 'Information Foraging Theory' (Pirolli 2007) is a singularly foundational and influential work. More recently and no less important is 'The Distracted Mind' (Gazzaley and Rosen 2016) which further develops information foraging theory from a neuroscience perspective. These two works, bringing together information and neuroscience, place a plausible bridge for researchers attempting to explain the phenomenon of the human drive to multitask. If we consider this as a partial framework or model for further exploration, then there is a more positive perspective on multitasking than has previously been published since one can then view it as part of our natural evolution and adaptive ability to gather and make sense of increasingly large volumes of information and data in this era.

1.3 Multitasking Is Multidisciplinary

It became apparent that there was a need to expand this chapter beyond the issues of education and to consider the advances in neurosciences and cognitive psychology. It was apparent that media multitasking and its effects have been investigated exhaustively in many ways. "The problem of how the brain undertakes multiple tasks concurrently is one of the oldest in psychology and neuroscience" (Verghese et al. 2016).

In 2009 a summit at Stanford University's Center for Advanced Study in Behavioural Sciences (CASBS) considered the impact of multitasking on learning and development. The purpose was to pull together a multidisciplinary, coherent and scholarly research agenda. Participants came from the field of neuroscience, child

development, cognitive science, communication, education, and business policy. Terms were agreed, including using the word multitasking itself, that multitasking had become a universal problem needing urgent attention. Solutions were being demanded by parents, educators, employers, workers, and marketers. Clifford Nass, a professor of communication at Stanford noted, "If you mention multitasking, people go insane—it's all they want to talk about". He described the problem of multitasking as "a challenge to human cognition" (Ophir et al. 2009).

1.3.1 Multitasking and the Brain

To better understand how distraction relates to multitasking we will explore a few aspects of neuroscience and our mechanical sensory capacities. To interpret multitasking, we need to consider the brain's attention networks underlying our ability to switch tasks (Rothbart and Posner 2015, p. 3). Neuroimaging has recently revealed that even subtle shifts in tasks activate neural areas (Rothbart and Posner 2015). The cerebellum has two areas of operation one that uses sensory signals and the other uses motor signals. In effect, the cerebellum is our *motor* for learning, particularly when it comes to learning new motor skills (Hatten and Lisberger 2013, p. 2). The cerebellum is capable of plasticity allowing a neuron to communicate with another neuron (this is a simplified explanation) in dynamic ways. For the most part, the mechanical and sensory parts of the brain operate together as long as a single task is involved. However, introduce more than one task and communication between these parts begins to break down resulting in the grave consequences of driving and texting (Kramer et al. 2007). Most of us have experienced 'going on autopilot' and driving from one destination to another without being fully conscious of the trip. This is experienced since we were likely thinking about something else during the mechanical process of driving–the learned mechanical process of driving has been saved to memory. However, introduce another mechanical process, say picking up a mobile, or a third–using ones' fingers to text, and even a fourth composing a text, and you have a recipe for disaster–the entire process becomes significantly diminished. In the United States alone nearly half a million people were injured or killed in accidents involving this combination of texting and driving (U.S. Department of Transportation 2017).

1.3.2 Action-Based Learning

The environment is significantly different in the classroom, still both the sensory and mechanical parallels for the brain exists with much less catastrophic consequences. Impaired listening or attention are significant to those trying to convey information to students who may be generally unaware that they are missing much of what is being

said. Recent research on plasticity regarding learning suggests that physical movement may activate the hippocampus in ways not previously understood (Cassilhas et al. 2016, p. 168). This discovery is significant concerning Action-based learning (ABL) approaches, since movement supports how the brain connects to preparing itself to learn. ABL is a process or pedagogy of brain-activated learning linked to the action of motor skills. This approach fits in well with the learner, requiring greater stimulus yet it has been observed that ABL is rarely discussed as a potential solution or even partial solution to the problem of distraction or inclination to excessively multitask in the classroom. (An omission that is addressed in this volume in Diane Kitchin's chapter on active learning.)

The problem of how we help students manage or break the cycle of multitasking in class may be diverted or rewired using methods like ABL. ABL requires substantial changes to the way lectures are planned and executed. The current state of most lecturing methods, where a long talk is involved, is yet another reason why lectures are becoming less able to facilitate learning and why ABL has come to the fore as one potentially rich approach.

1.3.3 Gen Z and Boredom

This year (2018) we will see our first Generation of students born between 2000 and the present: Generation Z (Gen Zers or Gen Z) has arrived in higher education. This generation was born into an Internet-connected world, has grown up with the smartphone, and may have spent the past decade using many social networks. The Gen Zers are a generation that prefers communicating through social media over direct communication. For the Gen Zers, waiting is not much of an option and they are conditioned to pick up their smartphone or device and find a release from the boredom. Since the arrival of the smartphone, waiting in lines at the store or for a train have become less of a problem. We can fill that time perusing the news, checking our social networks and email. Gen X and Zers use technology to 'personalise everything', they are technologically skilful and prefer Web applications and email (Reisenwitz and Iyer 2009, p. 91).

It seems logical that if students are physically active and working towards a goal or a solution to a problem they will be less likely to stop, pick up their phone and check Facebook–they will be less likely to want to interrupt their processes due to boredom.[2] This generation gets bored fast and the antidote to a nice hit of dopamine in checking in to social media. It activates them, and physiologically this generation has become accustomed to multitasking in this way in the same way that we would probably receive a similar hit from eating something satisfying.

[2] Our survey found 55% of students multitasked due to boredom. 62% identified lecturers reading from slides as another cause for multitasking during formal lectures.

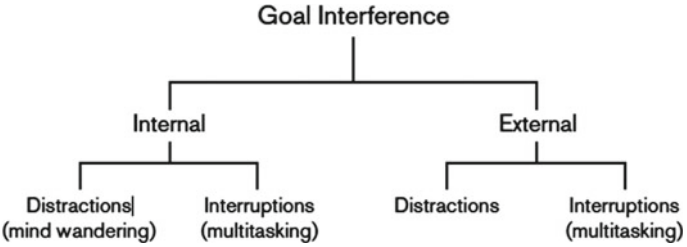

Fig. 1.1 Gazzaley's conceptual framework for goal interference

1.3.4 Cognitive Systems and Control

Cognitive control and its functions are central to the concept of multitasking. Although we cannot pursue this in depth in this chapter, some basic concepts are considered. Gazzaley breaks this down into internal and external factors about interference (see Fig. 1.1 (Gazzaley and Rosen 2016)). Interference represents those things that distract and interrupt us whether of our internal making or externally driven. The brain is a complex information-processing system. As a system, it is structured and optimised for performance. Again, in Fig. 1.1, Gazzaley shows how goal interference competes with internal and external factors as we try to achieve our aims.

Students, however distracted, are just trying their best to achieve their aims with often incomplete information about how to manage themselves. Perhaps there is a need to help them understand how they can optimise their work through understanding some concepts around multitasking. As discussed earlier, they are living in a more distracted environment than existed a decade ago or for us as academics when we were taking a degree. Of course, experience and management of goal interference will likely swing widely between the individual depending on countless variations. However, several areas can be supported in the classroom by adjusting our teaching methods, by considering recent research, and by embracing rather than negating technological changes.

1.3.5 Confirmation Bias and Supertaskers

Another issue brought up in both our survey and anecdotal with first-year students is the role confirmation bias plays alongside multitasking. Over the past two years, there has been a higher proportion of students who believe they are 'supertasker's' capable of rapid attention shifting with devices in what they believe to be efficiency. It is often talked about as a sought-after skill. It is true the way students often interact with a keyboard and respond to screen-based information is fast. Many studies have tested the supertasker phenomenon (Watson and Strayer 2010; Carr 2010). However,

current laboratory research still asserts that simultaneous task performance suffers during multitasking (Dux et al. 2009; Garner and Dux 2015). The problem is that speed and fluidity do not necessarily translate into the ability to apply it and learn new skills. Even more problematic, how do we help students to understand this when they believe what they have in a sense become indoctrinated into a cult of speed and freedom of unfettered access. Furthermore, studies of the brain have shown (Watson and Strayer 2010; Strayer and Watson 2012) there are only 2% of individuals capable of multitasking or do more than one thing at a time efficiently. However, employers seem to believe multitasking is a sought-after skill and regularly advertise it as such in programming jobs.[3] Also, students see other students with similar behaviours in class and come to believe that doing more than one thing at once is expected of them, to further exacerbate this problematic issue.

1.3.6 Academic Writing: A Bridge Too Far

Writing is a higher-order learning skill. It is also an area where academics have seen significant and growing difficulties for students. It is possible that the rise of essay mills may well be related to the problems students are facing having to write an extended academic paper. If, as mentioned earlier, many students are experiencing a reduced depth of processing, increasing stress levels including anxiety due to multitasking, then their ability to invoke creative problem solving will ultimately be hampered (Firat 2013). We are finding that fewer students are often only capable of shallow focus work (Carr 2010) leaving them unable to tackle harder work requiring greater cognitive power and focus. So it is not only the focus, but academic writing is a difficult task that requires deeper thinking and higher cognitive skills than what current students spend most of the time doing, both inside and outside the higher education environment. These problems become most visible in the third year when they are asked to develop a dissertation, a large piece of writing requiring work over an extended period. They are less prepared for this challenge, and we need to do more to assist them constructively. It is likely that various variables are at work here from brain and neurological functioning to insufficient awareness and ability to manage distractions effectively. Add to this the inability to manage and focus attention in the sea of the increased use of social media, all these factors are contributing to the problem.

GOT TO HERE.

[3] Searching the word "multitasking" site:indeed.com and "multitasking" site:indeed.co.uk show a difference of 73,300 US compared to 6760 UK. This may suggest a difference in educational and employment emphasis. It could also be just a reflection of population differences.

1.4 Debating the Banning of Laptops During Lectures

Moving now from our increased understanding of why students multitask and how the brain functions we can further explore the impact these are having in the classroom. One of the standout factors aligned to multitasking in the classroom is social media usage. In 2005 Facebook and MySpace were launched, closely followed by Twitter and YouTube in 2006. The exponential shift happened a few years after the launch of smartphones including the iPhone in (2007), and the 2008 launch of the Android mobile operating system in 2008. It then took several years for mobile computing to appear in classrooms where more than half the class were in possession of a mobile. In 2010 only a few students had them, but the increase has become pronounced and new problems around attention and distraction arose. Smartphones are cheaper, faster and the operating systems less fraught with technical issues. By 2015 virtually every student had a smartphone in the classroom and often more than one device. This fast pace has put stresses on the higher education system and our ability to adapt our teaching methods at pace with these changes. Combine this with social media usage, and one has a perfect storm.

By the fall of 2016, social media usage amongst university freshman in the United States averaged over six hours a week, an increase of over 40.9% or 27.2% greater than in 2011 and 2014 (HERI 2017, p. 20). There were over 10 million participants in this survey. Being an election year in the United States may have had some impact on this data. However, if social media continues to increase at a similar rate, what changes are likely in the classroom? Will increased usage of social network sites (SNSs) amongst students increase distraction and attention levels in the classroom and if so how will we adapt our methods? It is essential to develop strategies to improve engagement in this changing environment as well as considering both cognitive and information systems models as part of that development. As professors and lecturers across the globe experiment with various approaches to control these relatively recent changes, we see both extreme and light touch reactions. One wing demonstrates only a modest understanding of the collision of human-to-human and human–computer interactions at play. For example, Seth Godin[4] taking an oppositional stance towards Susan Dynarski, a professor at the University of Michigan. Dynarski published an op-ed in the New York Times stating that she has forbidden students from using laptops in her lectures (Dynarski 2017). Godin believes Dynarski has missed the point altogether. According to Godin, Dynarski is laying the blame in the wrong place by asking students to slow down their clock speed and listen attentively in addition to notetaking—all at the same rate. He argues this is unreasonable to expect this given the technological changes in recent years and lays some blame on universities not adapting quickly enough either. Godin states "the solution isn't to ban the laptop from the lecture it's time to ban the lecture from the classroom" (Godin 2017). He also believes the lecture should be digitally recorded so students can review it, as and when they choose to. However, the problem may not require institutions to do away with

[4] Seth Godin is a well known entrepreneur, bestselling author, writer and marketing and leadership blogger.

the lecture hall, and it is worth considering the possibility of something in between these two somewhat extreme ends of the spectrum. Shorter lectures formed of no more than five to seven minutes followed by activities to discover information closely related to the presentation may be more motivational and engaging. The traditional 45–60-min lecture is still currently the norm but is unsustainable given the changing environment. There are a number of arguments against banning laptops, not least of whether such a ban would be compatible with an ethos of open education and how such a ban might be enforced. There is the question of potential discrimination against students with disabilities, or if some students were allowed laptops to support their disability, discrimination against students without disabilities. Furthermore for "Zers" a laptop or smartphone may be the most efficient way to take notes and to instantly look up additional information. Some research suggests that students who multitask using their laptop during lectures perform less well compared to those that do not (Sana et al. 2013). However, one must ask—if students had more advice on *how* to take notes optimally, would this study still be valid? The early days of email usage in the mid-nineties had a pretty steep learning curve and compared to numbers of technologies and applications we have now it seems an almost silly comparison, yet we all struggled with learning how to manage it. Academic staff misused and overused the medium while simultaneously bemoaning the extra workload. We may have to consider students similarly don't know *how* to manage their devices optimally to improve their performance. Sana's study above was only investigated with forty participants. A limited sample suggests a need for a more comprehensive study that also considers using an intervention method as a control group and then comparing the data similarly to a study undertaken at Ryerson University (Tassone et al. 2017, p. 1).

1.4.1 Note-Taking

The research on note-taking goes back to the 1960s where there was considerable debate about how and when to listen and take notes (Eisner and Rohde 1959). It is worth having a brief look at how note-taking fits into the multitasking debate. Many researchers believe that taking notes on a laptop will impair performance compared to those who take notes longhand (Mueller and Oppenheimer 2014, p. 1; Bellur et al. 2015, p. 65; Fried 2008, p. 47). The problem is not the technology or mandating rules to comply with it. The problem is more precisely that students need assistance managing the interplay of these issues. Generally, most studies tend to support a rule or discipline-based solution in the classroom more or less finding fault with the student, the technology or the social media networks and default towards asserting that students must follow "proper rules […] and abide by these rules" (Anshari et al. 2017). This approach mainly describes the problem but misses the importance of considering a model sensitive to context, changing cognitive conditions and human-systems design persistently shaping behaviour and influencing human evolution.

1.5 Smartphone Dependencies

Dependency on smartphones and academic performance is another area aligned with variables contributing to multitasking. There has been a plethora of research over the past decade on this topic (Samaha and Hawi 2016; Junco 2012, pp. 505–514) is well- documented students were almost in a state of discomfort having to turn off or look away from monitors or devices during the formal part of a lecture. There are many issues at work here. Firstly, students have become used to large amounts of visual activity and stimulus with the average 19-year-old checking their phone every ten minutes. Secondly, most students have had a smartphone for at least five years or more and lived in a context where these technologies have been an inseparable part of their daily lives. The smartphone has become an object of instant gratification, a quick fix for boredom and has neurologically altered their brains and consequent behaviours. Often this is leading to a form of addiction (Terry et al. 2016, p. 245). We can now confirm this has changed our students' brains having grown-up in tandem with smartphones and mobile computing more (Loh and Kanai 2015, pp. 2–3). If we can accept this, then much of what has been discussed in this chapter should begin to make sense. With this in mind try to imagine what a student would be experiencing in the average university classroom. Imagine how frustrating it would be to sit for extended periods while the lecturer reads from slides. This approach is still occurs in many lecture halls in both the United States and the UK. The lecture format will likely not keep students engaged unless it is short (5–7 min), targeted and has a specific outcome followed up quickly by an information consolidation activity. So, we currently have a problem, and it is not with the student–we are missing opportunities to create engagement in the classroom.

1.6 The Survey

A survey on multitasking was carried out between March 21st–31st 2017 on a cohort of 60 undergraduate students taking a first-year, core, web development module. The students were asked to describe their multitasking habits during formal lectures. The study aimed to discover perceptions about multitasking behaviour.

A Likert scale was used for 22 questions. A 23rd question asked if they would like to share their thoughts. The Likert scale was especially useful for establishing some evidence of a possible correlation between high percentages of neutral answers and whether questions were either too broad or vaguely stated. (Thedetail of these results has not been included.) The highest neutral score was 42% for the question: *I believe multitasking during lectures is a smart thing to do.*

1.6.1 Intrinsic Questions

Four questions were similar for a reason. These were questions about whether participants would change their minds about multitasking. 60% were willing to change their minds if multitasking proved to them it could: lower or improve their grades (66%), harm their learning (60%) or improve their learning (48%). 55% believed they could get more done with 43% thinking it made them more efficient.

1.6.2 Extrinsic Questions

Just 58% of the students said they were using one or more devices to multitask during their formal lectures. This result is generally in line with other studies. The reason for this appeared to be that they felt they could get more done 55%, while 62% said they multitasked because lecturers were reading from slides, while 55% said their multitasking was due to boredom during the lecture. In some ways, this is encouraging as a change in teaching approach may result in more active or participatory learning. No students felt any pressure to multitask by their lecturers (0%).

1.6.3 Employability

In 2012 at the CASBS summit, Clifford Nass stated: "companies now create policies that force their employees to multitask". In our study, just 11.7% thought multitasking would make them more employable. This result demonstrates an opportunity to raise awareness amongst students for employability purposes. Oddly, 40% said they believed multitasking to be an essential skill. There has been an increasing frequency 'multitasking' appearing in job posts for software developers. This response is interesting despite evidence multitasking skills are often sought by employers. However, there is a difference in emphasis between the United States, and the United Kingdom[5] in this regard. Oddly respondents did not consider multitasking to be an employability factor as highlighted in some research (Burak 2012; Crenshaw 2008).

The survey shows some evidence that computer science students in the UK have varied views on whether multitasking during class lectures is positive or negative. Though one comment did not see the point of the survey or why their views about it would be interesting. This response suggests students need more information about

[5] Searching the word "multitasking" site: indeed.com and "multitasking" site:indeed.co.uk show a difference of 73,300 US compared to 6760 UK. This may suggest a difference in educational and employment emphasis. It could also be just a reflection of population differences.

this for their continuous and focused information-seeking behaviours about multitasking. Similarly, lecturers may want to alter teaching methods to reflect the changed cohort as mentioned earlier. Students also appear to want the facts about multitasking as there seemed to be some slippage between what they believe and what may help them in their studies and professional life.

1.7 Conclusion

Early on in this research project, it became apparent that the study needed to expand beyond issues of education and therefore consider the recent advances in the cognitive neurosciences and cognitive psychology. It also became clear that media multitasking and its effects have been investigated exhaustively in many ways. "The problem of how the brain undertakes multiple tasks concurrently is one of the oldest in psychology and neuroscience" (Verghese et al. 2016). What has been offered in this chapter is the breadth and depth of the challenge ahead and to some extent behind us as mediators in the classroom. Further advancements and changing frontiers in the sciences are still being discovered and how much Gen Zers brains have been altered is becoming apparent. However, as Susan Greenfield asserts "the brain is exquisitely adaptable" (Greenfield 2015) and further research will likely bring enhancements possible for our ongoing adaptation concerning information foraging. It is also possible that with these advancements there will be more 'supertaskers' among us (Strayer and Watson 2012). Video games are an indication of this and have been shown to be highly beneficial to multitasking particularly with older participants (Mishra et al. 2016). These developments indicate not all aspects of multitasking mean poor performance as some researchers assert (Bellur et al. 2015, p.65). Changes are underway that will continue to test us as educators though, and students will require specific and targeted guidance about the risks and benefits of multitasking has as they manage their courses, careers and lives. However, I would suggest that there is one conclusion we can certainly draw. Multitasking is prevalent, and it is here to stay. We can either choose to rile against it, or adapt our methods to accommodate it. Accommodation would seem to be the more productive approach and possibly the less stressful one. It might well be worth considering how best to incorporate the changes learning environment into our teaching.

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