Developing a Case-Based Learning Module on the Science of Learning

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Abstract

Background: There are effective and ineffective approaches to learning. In medical education, appropriate coverage of evidence-based learning strategies is lacking. Undergraduate medical learners could benefit from having foundational knowledge on learning strategies.

Methods: Review of the literature was used to help develop appropriate objectives and resources for the science of learning targeting early undergraduate medical students. Local curriculum was reviewed for current content and optimal placement of this material.

Results: Dalhousie's undergraduate medical Professional Competencies curriculum was identified as an appropriate target for implementing a medical education tool on effective learning strategies. Both a didactic lecture (video recording) and a case-based tutorial module (text document) were developed in keeping with the current curriculum format.

Introduction & Background

The path to becoming a physician requires learning a vast amount of new material and developing mastery of it. Students enter medical school having adopted learning and study habits that, given the rigorous entry requirements, have likely served them well in the past. It is not unreasonable for students to assume that continuing with these habits is optimal for learning to practice medicine.

Additionally, learners will undoubtedly be given advice at various stages in their medical studies, from student support services, professors, staff physicians, residents, more senior students, and peers. The quality of this advice varies greatly.[1–3]

Fortunately, there is a well-established body of evidence from cognitive psychology to guide learners and educators on the most evidence-based approaches to learning effectively.[4] Among the learning strategies that are most effective are the inter-dependent concepts of spaced repetition, retrieval practice, interleaving, and elaboration.[4–6]

And yet, many of the techniques that have emerged through the evidence are not widely used by learners.[7] As we, the authors, are familiar with the Dalhousie Medical School Undergraduate curriculum, we see a significant lack of coverage of the science of learning. As such, the goal of this report is to generate a medical education tool in the form of a lecture and tutorial on the science of learning targeted at early undergraduate medical students as part of Dalhousie's "Professional Competencies" component of the undergraduate medical curriculum.

Why is this important?

Family physicians are uniquely tasked with established medical expertise in an incredibly broad scope of knowledge and skills, as well as the duty to teach those same skills. There is a high value placed within the profession on “clinical excellence”[8,9], “continuous learning and teaching others”[8], and “commitment to reflective practice.”[9] In addition to the breadth of knowledge required for the training and practice of family medicine, we would argue that the teaching responsibility that is vital to the profession requires more than just a communication of knowledge; it requires a teaching of *how* to learn such breadth. As such, we view this as important material both to deliver to medical students early in training to better prepare them should they choose a career as a generalist, and to add this work to the collection of projects

within the Department of Family Medicine as a resources and reminder about the importance of discussing the process of learning.

Methodology

Seeking to develop a medical education tool on the science of learning targeted at early medical students means two things: 1) reviewing, assessing, and collecting relevant literature, and 2) looking at the undergraduate curriculum to understand where this material would best fit. Ideally, this topic would be incorporated as a longitudinal theme but that remains beyond the scope of this work.

The Science of Learning

To summarize the key points of the current understanding of the science of learning was not a novel concept to us, as this has arisen from a general interest and attempted application of these concepts in our own journey as learners. The immense volume of published work on this topic means that a fully comprehensive assessment of the literature is beyond the scope of this report, thus the literature was assessed for common themes, with reference to some excellent review sources that will be mentioned here.[4–6,10,11]

The common themes we wish to highlight are: 1) humans are poor judges of when learning is effective, 2) ineffective learning strategies continue to be used heavily, 3) effective learning strategies exist and should be implemented, and 4) catering to specific learning styles does not improve learning.

How do we know what we know?

Learning is the process of taking some piece of information and adding it to long term memory so that it can be used and retrieved later. This is understood, from a neurocognitive perspective, to involve three steps that necessarily create physical and chemical changes in the brain[4,5]:

1. Encoding – bringing information into short-term memory, which involves translating perception into a representation in the brain (*memory traces*)
2. Consolidation – strengthening, stabilizing, and organizing the memory traces for long-term memory. Sleep plays key role here.
3. Retrieval – Accessing the learned information, which further strengthens the memory.

Most would agree that the value of learning is in retrieval, especially as it applies to medical education, as the goal is to be able to apply our learning to the clinical environment. It doesn't do the clinician or patient much good to claim to have a knowledge of how to manage decompensated heart failure yet be unable to retrieve that knowledge when it is needed.

Humans are notoriously poor judges of when we are learning, and when that learning is effective. We are easily deceived by fluency illusions, ease of practice, and quick gains, which will be described here.

Fluency illusions result from our tendency to mistake fluency with a text for mastery of its content. This means, while re-reading a text to “brush up”, the familiarity of the concept leads us to over-estimate our ability to retrieve that content later, when it is needed.

Ease of practice is falsely reassuring because evidence suggests that durable learning requires *desirable difficulties*. That is, in order to create memories or skills that are durable and retrievable, the learning requires some difficulty.[12]

Quick gains occur when there is *massed practice*, the “single-minded, rapid-fire repetition of something you're trying to burn into memory, the 'practice, practice, practice' of conventional wisdom." [4] This is a common experience, which is why massed practice is so ubiquitous; quick gains feel good and are easily perceived. Unfortunately, the gains from massed practice do not persist without appropriate repetition and spacing.[13]

The self-deception that is caused by these concepts leads learners to favour study habits that lead to relatively rapid acquiring of new skills and memories that fade almost as rapidly as they were acquired. *Cramming*, *massed practice*, and *highlighting* are examples of such habits that continue to be used because they often lead to success as measured by infrequent, independent high stakes assessments that are often seen in post-secondary education. Yet, evidence (and experience) demonstrates that these habits do not lead to durable long-term memory. [4,14,15] This may be tolerable in certain learning situations. In medicine, however, where

there is an expectation of expertise, such a large amount of forgetting is unsafe and should be prevented.

The takeaway is that humans are poor judges of when our learning is effective and durable, which leads to poor study habits and thus poor integration of new skills and information into long-term memory that is readily retrievable. Fortunately, there are well-described learning strategies that, when implemented, have been shown to lead to longer lasting memories, better conceptual understanding, and ultimately better retrieval ability when needed.

Effective learning strategies

Retrieval-based learning

"Retrieval interrupts forgetting."[4] Using retrieval as a method of study strengthens memories making them better able to be recalled when needed.[14–16] Retrieval is also helpful in assessing gaps in knowledge and where to focus further study. Without objective evidence of weaknesses, we often fail to target our learning appropriately. Retrieval can take the form of self-driven testing or flashcards, or any more formal example of testing in a classroom or clinical setting. This takes advantage of the *testing effect*, the idea that testing "enhance[s] later retention more than additional study of the material, even when tests are given without feedback."[17]

Spaced Repetition

In contrast to *massed practice*, or *cramming*, spaced repetition is the act of periodically returning to material. It is an effective strategy to prevent forgetting.[18] In particular, it has been

purposefully applied and studied in medical education in numerous contexts, from medical school to Continuing Professional Development.[19–23]

Interleaving

Another concept that contrasts with *massed practice* is *interleaving*. It is the act of varying the topics/skills that are focused on within a single session. Rather than spending prolonged time focused on one topic/skill, the learner may move on to another before the first skill is "done," with the intention to return later (a form of *spaced repetition*). This usually leads to slower acquisition of skills and knowledge on each topic that is studied, which can lead to frustration, but research suggests this slower acquisition is much more durable than what would be seen with rapid gains seen in massed practice.[12]

Elaboration

Learning is more durable when it is meaningful.[24] *Elaboration* is the process of giving new learning meaning by summarizing using your own words and fitting it into a context of prior knowledge. "Learning is stronger when it matters, when the abstract is made concrete and personal."[4]

Metacognition

All of the above strategies are not only meant to help improve the quality of learning, but when combined together can also help the learner know more *about* what they know, i.e. *metacognition*. As described earlier, poor learning strategies tend to evolve out of an

inaccurate assessment of the quality of learning. Sharpening our *metacognition* counteracts this shortcoming.[4]

Learning styles are myth

The VARK (visual, auditory, reading, kinesthetic) paradigm first described by Neil Fleming suggested that there are specific modalities of learning, and when instruction and study are tailored to match that of the preferred modality of the learner, the learning will be better.[25,26] This paradigm, however, is one of many paradigms that exist to explain learning differences, but what they all have in common is the idea that learning is better when delivered in a style that matches the preferred style of the learner.[4] This idea has been well-reviewed in the literature and it unfortunately does not have any evidence to support it.[27] Learners may still *prefer* learning through certain modalities, but what the literature refutes is that following preferences improves the *learning*.

Professional Competencies Curriculum

As mentioned above, continuing education and lifelong learning is a professional competency of physicians. Given that Dalhousie Medical School has a Professional Competency ("Pro Comp") unit in the undergraduate curriculum which provides an "opportunity to integrate your biomedical and clinical learning within the context of patient care from a professional, community and life-long learner perspective,"[28,29] it was deemed an appropriate target.

The Pro Comp sessions consist of a weekly one-hour large-group session/lecture, followed by a two-hour, usually case-based, small group tutorial session, covering a different topic each

week. Each large and small group session has a set of learning objectives that they set out to cover as determined by Dalhousie's curriculum. The large group sessions can take on different formats, from a summary of the topic for the week, to a panel discussion on the topic. We have chosen to prepare a lecture providing a summary of the science of learning with some recommendations for students.

The cases usually consist of preparatory reading material and questions that students will have completed before the session that they will come prepared to discuss in their small-group tutorials. There is frequently a small number of "universal readings" which all students are expected to have read, and a larger number of "divided readings," from which each student selects a subset to read to allow for discussion from different perspectives. The readings can be journal articles, position statements, perspective pieces, media articles, or even videos to watch, all of which help to educate the students, cover the objectives of the session, and generate discussion in the tutorials.

Reviewing the Pro Comp material from the 2017-2018 and 2018-2019 provided a basic framework development of objectives, didactic lecture, and tutorial. The didactic session was recorded and tutorial guides were created, which included both a student guide and a tutor guide containing answers and key discussion points.

Results

Didactic Session

The objectives set were determined by the authors. Any objectives that would be incorporated into a curricular element would of course be vetted, discussed, and adjusted accordingly through a well-defined process, but we feel this set is a useful starting point to capture what we would hope to communicate. Objectives are listed in Box 1. The session was created and recorded by David Brandon. It is a 32 minute lecture that is an appropriate length to allow for group discussion, addition of new material should it be deemed necessary, and flexibility.

By the end of this lecture, you will be able to

1. Define and describe well-established evidence-based learning strategies: Retrieval-based learning, Spaced repetition, Interleaving, Frequent testing, Elaborative interrogation and self-explanation, Metacognition
2. Describe the pitfalls with commonly used study techniques: massed practice, reading as a form of studying, highlighting, cramming
3. Understand and discuss the limitations of using learner subjective judgement to assess quality of learning activity.

By the end of this tutorial, you will be able to:

1. Apply the concepts discussed in the lecture to assess and critique quality of current learning strategies through cases and self-analysis.
2. Develop and make plans to implement evidenced-based learning strategies.
3. Use your knowledge of evidence-based learning strategies to analyze system-level learning and where there is room for improvement.

Box 1: Objectives for lecture and tutorial components

Tutorial

Similarly, tutorial objectives were determined by the authors and are listed in Box 1. The tutorial was developed to follow two medical students through the transition into medical school and the learning challenges that are often faced, both based on experience and evidence

of approaches that students take to learning medicine.[7] The goal is that students would related in some way to their own journey and in so doing improve their metacognition skills. We have also included some opportunity for designing a learning plan as well as to discuss the medical school curriculum and its support or lack thereof for evidence-based learning strategies.

Discussion

Students begin their medical education with different backgrounds and skillsets. It is clear from the literature discussed that the strategies of evidence-based learning are poorly understood and infrequently utilized. With guidance of the literature and an assessment of the Dalhousie Medical School undergraduate curriculum, a cased-based learning medical education tool was developed targeted at early medical undergraduates with the goal of helping students develop good habits early in their training, as well as perpetuate the importance of these ideas as students transition to become educators.

This is of particular interest to the field of family medicine, where a wide variety of unrelated material must be mastered in order to be a “skilled clinician”. Family physicians are well-suited to be not only experts in clinical care of patients across the lifespan, but experts in the education of future physicians across the learning journey. As such, we feel that the generalist nature of family medicine has the most to gain from a stronger adoption of the aspects of the science of learning.

Conclusion

The project aimed to provide a summary of common strategies of evidence-based learning strategies, and develop both a lecture and small group tutorial guide use as an educational tool for early undergraduate medical students. Implementing into the curriculum is beyond the scope of the current project, but this serves as a starting point should there be room to implement in the future.

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Appendix – Medical Education Tool

Lecture: https://dalu-my.sharepoint.com/:v:/g/personal/dv536780_dal_ca/EdKm7WL8BRlJo9bJHNoqi1kB-M6mdlazhjNpeZPCtPz3TA?e=CBj5my

Tutorial Tutor Guide (below)

A Case of Learning Challenges

(This is a **tutor guide**, the student guide will not have answer boxes)

Case Author: David Brandon
Date Created: March 2023

Lecture objectives

By the end of this lecture, you will be able to

1. Define and describe well-established evidence-based learning strategies: Retrieval-based learning, Spaced repetition, Interleaving, Elaboration
2. Describe the pitfalls with commonly used study techniques: massed practice, reading as a form of studying, highlighting, cramming
3. Understand and discuss the limitations of using learner subjective judgement to assess quality of learning activity.

Tutorial objectives

By the end of this tutorial, you will be able to:

1. Apply the concepts discussed in the lecture to assess and critique quality of current learning strategies through cases and self-analysis.
2. Develop and make plans to implement evidenced-based learning strategies.
3. Use your knowledge of evidence-based learning strategies to analyze system-level learning and where there is room for improvement.

Universal readings

U1 - Bjork EL, Bjork RA. Making things hard on yourself, but in a good way: Creating desirable difficulties to enhance learning. In: *Psychology and the Real World: Essays Illustrating Fundamental Contributions to Society.* Worth Publishers; 2011:56-64.

Divided readings

D1 - Moulton CAE, Dubrowski A, MacRae H, Graham B, Grober E, Reznick R. Teaching Surgical Skills: What Kind of Practice Makes Perfect? *Ann Surg*. 2006;244(3):400-409. doi:10.1097/01.sla.0000234808.85789.6a

D2 - Piza F, Kesselheim JC, Perzhinsky J, et al. Awareness and usage of evidence-based learning strategies among health professions students and faculty. *Medical Teacher*. 2019;41(12):1411-1418. doi:10.1080/0142159X.2019.1645950

D3 - Parmelee D, Roman B, Overman I, Alizadeh M. The lecture-free curriculum: Setting the stage for life-long learning: AMEE Guide No. 135. *Medical Teacher*. 2020;42(9):962-969. doi:10.1080/0142159X.2020.1789083

- Especially page 963-964 on learning

D4 - Karpicke JD. Retrieval-Based Learning: Active Retrieval Promotes Meaningful Learning. *Curr Dir Psychol Sci*. 2012;21(3):157-163. doi:10.1177/0963721412443552

Case

We be exploring the stories for Grace and Hana, first year medical students who are about 8 months into their program.

Grace

Grace completed an undergraduate degree in biochemistry where she achieved a high GPA, several scholarships, and, of course, acceptance to medical school. Most of her undergraduate courses followed a standard format of lecture-based course delivery, some with lab sessions, and assessments usually took the form of 1-2 mid-terms and a final exam. Mid-terms and quizzes were rarely cumulative, they covered new material each time.

Through her studies, Grace developed a reliable pattern of test prep. About 1-2 weeks before exams, she would begin re-reading her notes that picked up around the time of the last exam. Starting early usually gave her enough time to re-read her notes 3-4 times before the exam. If relevant, she would occasionally do practice problems. If there were lists or structures she had a hard time committing to memory, she would spend the night before the test trying to commit these things to memory since that was when she found the hard-core memorization most useful.

With this strategy, she would almost always do well on her tests and exams. Seeing her success, she continued with these strategies and they continued to serve her well.

While preparing for the MCAT, which covered topics that she already taken courses in and excelled, she was surprised to realize how much she forgot, and how much studying would be necessary. This frustrated her, but she knew that if she applied her usual

techniques, everything should work out. Sure enough, her MCAT score was not exceptional, but was satisfactory for admission, further affirming her skill for studying.

In medical school, Grace continued to do well, performing slightly above average on her exams. She was always prepared for her case-based sessions, simulation sessions, and clinical skills sessions. Up until this point, she was quite happy and confident in her ability to perform well in medical school, has she had done throughout her academic career.

Hana

Hana completed her undergraduate studies several years ago. She studied psychology and went on to complete a Masters in Social work, and has been working as a clinical counsellor ever since. Her during her studies, she mainly prepared for tests by re-writing notes that she had taken from lectures and textbooks. She found the act of re-writing helped her to commit things to memory. If it was a particularly difficult topic, she would re-write her notes several times. She did well enough in undergrad, but did not excel. She continued to use this strategy during her masters, with better effect. However, she has some health issues during her masters that affected her ability to maintain the same priorities she was able to maintain before, between work, hobbies, partner, and social/personal life. Realizing that her highest priority in that time was to get through her studies, she made sacrifices so that she could be successful, and she was.

While she was excited to start medical school, the difficult memories of graduate schooled gave her some pause. She told herself that things would be different and that she would work hard to schedule her studying in such a way that she would be able to maintain a life outside of school. However, 8 months in, the volume of new information made her realized she would have to work many more hours than she thought to stay on top of the material. Re-writing notes was working for her, to some degree, passing all of her exams with a mark a bit below average, but she is now burnt out and is realizing this is not sustainable. She is struggling with her confidence and is wondering what she can do to improve her ability to keep up.

Question 1: Both stories explore elements of study strategies and their development, successes, and frustrations. Is there anything in that you resonate with?

Tutor Guide
Encourage students to share their own stories, whether they are similar to these or not. Some prompting questions could be:

- *How are you finding the material in medical school so far?*
- *What study strategies have you implemented? Are these new to you or were they habits you had before medical school?*
- *How do you find the learning in medical school different from other learning environments?*

Question 2: What study strategies are being implemented by these 2 students?

Tutor Guide
Grace: re-reading, massed practice, cramming
Hana: re-reading/writing, massed practice, cramming

Question 3: Grace has been quite successful with her studying so far. Based on the evidence from cognitive psychology, should she set out to make some changes? What

Tutor Guide
The main point to get across is that the evidence suggests that while Grace's strategies work very well for individual test preparation, they do not work well for long-term retention. If both of these students want to maximize long-term retention with the minimal effort possible, they should be switching to more evidence-based strategies (e.g. retrieval, interleaving, spacing, elaboration...).

We also want to encourage the students to be honest about their opinions on these topics, and if there is strong push-back or disagreement with the evidence-based principles, to encourage open minds, just as we would encourage with patients who don't agree with evidence for smoking cessation, cardiovascular disease prevention, immunization, etc.

The goal is not to force students into agreeing with all that is said, but generate discussion, introspection, and reflection as part of a process of learning how to learn.

do you think? What issues do you see these 2 students facing if they continue these strategies?

Question 4: You read about the concept of desirable difficulties. What does it mean for difficulty to be *desirable*? Hana appears to be facing some difficulty, is her challenge with learning a good example of a desirable difficulty? Why or why not?

Tutor Guide
Desirable difficulties his discussed in the Bjork & Bjork chapter "Making things hard on yourself, but in a good way: Creating desirable difficulties to enhance learning".

Learning is stronger when there is some level of difficulty, but difficulty in and of itself does not produce durable memories. Desirable difficulties are the difficulties that arise when engaging in productive, evidence-based learning strategies, and are meant to produce durable learning.

"Many difficulties are undesirable during instruction and forever after. Desirable difficulties, versus the array of undesirable difficulties, are desirable because they trigger encoding and retrieval processes that support learning, comprehension, and remembering. If, however, the learner does not have the background knowledge or skills to respond to them successfully, they become undesirable difficulties." (Bjork & Bjork)

In this case, Hana is facing some difficulty, but based on both her performance, and comparing her methods of study with those shown to produced good learning, her difficulties would be considered non-desirable.

Grace and Hana are now both 2 weeks into their family medicine clinical placement which they attend 1 half day per week. They have each been given opportunities to take histories and examine patients. When the placement started, they had quite different attitudes. Grace was excited to see some things on the patient list that she knew she covered in her medical school curriculum already (for some examples, anemia, vomiting and diarrhea, constipation, diabetes, osteoporosis). Hana, however, approached the rotation some fear that she would not do well. She was struggling with her confidence as she felt she was putting in so many hours with little to show for it. Hana also saw Grace's confidence and success, and was worried about being compared to a "better" student.

Now 2 weeks in, Grace quickly realized that without knowing about these cases ahead of time and being given the opportunity to prepare, when quizzed on her knowledge of these topics (in a safe and constructive way), she would remember little of what she previously studied and knew well. This really began to shake her confidence, which was a first for her in his studies.

Hana performed similarly (perhaps even a bit superior to Grace given her strong interpersonal skills), which, given her lower expectations, was a pleasant surprise. She gained some confidence, but they were now both in this situation where, although their strategies and test performance were different, their ability to recall information they already covered when it was needed was similarly weak. It was not that they were struggling with topics on material they hadn't covered yet, it was that they were struggling quite a bit with material that they *had* already covered. They both had the realization something had to change.

Question 5: Have you had or heard about others having similar experiences?

> ***Tutor Guide***
> *Encourage discussion.*
>
> *Can prompt learners with some questions:*
> - *How do you find preparing for a test vs preparing for clinical placements?*
> - *Have you had to make any adjustments in your study strategies since starting medical school? What did that look like?*

Grace and Hana decide to look for some resources to help with their studying. As is often the case, they start with a google search for "how to study in medical school". The top 3 links they get are the following:

- 10 Tips on How to Study for Medical School. AUC School of Medicine. Published April 12, 2022. https://www.aucmed.edu/about/blog/medical-school-study-tips
- Doctors Offer Insider Tips on How to Study in Medical School. Medical Blog. Published August 5, 2021. https://www.sgu.edu/blog/medical/how-to-study-in-medical-school/
- How to Study in Medical School in 2023. BeMo®.https://bemoacademicconsulting.com/blog/how-to-study-in-medical-school

Question 6: Skim the above resources. Do you find any useful information here? How does the advice compare to some of the evidence-based learning strategies we have used?

> ***Tutor Guide***
> *The information is from the top google search results at the time of the writing of this case (early 2023).*
>
> *The information is not useless, and there are some easy tips that could help some, but the main concept to get across is that these tips are seriously lacking in adequate explanation of the concepts that evidence suggests really do make a difference. They do mention some form of recall, but it is a small part of the long list of marginally helpful advice.*
>
> *Not only is there is also a lack of explanation or data to back up these recommendations, but some resources continue to follow the myth of learning styles.*
>
> *It is clear that the authors of these articles do not have expertise in the science of learning. The quality and rigour of the study advice from these resources is comparable to health advice you might get from a blogger or influencer online. Just as we send patients to read trusted, evidence-based resources for their health information, we should also strive to look for evidence-based resources for learning tips.*

The wealth of information online is varied and sometimes contradictory. It is difficult to know where to start. The students decide to reach out to their preceptors to decide how best to learn.

Their preceptor, Dr. Grey, suggests doing what worked for him in medical school: "reading around cases". He tells them: "after each day, pick 1 or 2 cases you saw and read around them later that evening. That way, connecting the real person with the case means that you will never forget it. Every time you encounter that problem again, you will think of that one patient you saw."

Question 7: Have you heard advice like this before? What do you think about it in light of what we are learning in this session?

Tutor Guide
This advice is not useless, it is a useful habit to incorporate into a study plan, but as a response to the question "how do I learn in medical school?", it is seriously lacking in the most basic information that really does help with learning.

Note to tutor: Can prepare students for the huge number of times they will hear advice like this throughout their medical training.

A point that was emphasized in the lecture accompanying this case, is that most medical learners will pass the exams they need to pass, and will learn the things they need to learn to practice medicine in a mostly safe and competent way. The goal of communicating this material is not that it is the only way to be a good physician, but in the long run, it provides the most efficient path that can maximize skills while minimizing stress and burnout (at least as it relates to learning).

The students both take this advice. Over the next several weeks, they think of 1-2 cases they saw and do some reading around it.

Grace's strategy is to spend 30-45 minutes reading about the cases as soon as she gets home from clinic, while the memory is still fresh. She takes some notes as she reads, and feels that she is doing some good learning.

Hana's strategy is different because she does not have as much free time as Grace. When she gets home, she takes 10 minutes to reflect and write down some questions about her cases that she wants to research answers to when she has the time (usually on weekends).

Grace notices mild improvement in her ability to handle cases similar to ones she has seen before and read about, but Hana notices quite a marked improvement.

Question 8: Why do you think there is now such a difference in their ability to recall information when needed clinically?

Tutor Guide
While they are both "reading around cases", Grace's strategy does not really implement any evidence-based learning strategy.

Hana, on the other hand, is engaging in both reflection, generation, and spacing. These are working to generate stronger memories and she is more able to recall information when she needs it. There is still room for improvement in her strategy, but it is moving in the right direction.

Notice that in this case, the 2 students are spending comparable time studying the material. Hana may spend an extra 10 minutes on the question generation, but the returns on this extra time, when combined with effective spacing, are significant.

Question 9: Exercise - Suppose either of these 2 students were starting a new unit or new year in your medical school curriculum? How would you design a learning plan that implements evidence-based learning strategies? Consider looking at your weekly schedule, and add some self-scheduled time for study.

Tutor Guide
There is no one right answer here. The goal is to encourage students to reflect on a routine could be developed around their medical studies.

Encourage the students to think carefully about all the obligations that a medical student might have for the week, including social time, exercise, leisure. The goal is to move away from a reactive schedule that gets much busier and stressful as due dates or exams arise, to a schedule that spreads this over the whole of the year.

For example, they may start with asking what is a reasonable number of hours to spend on their studies for a week, then working backward from there is figure out how to prioritize these hours.

Do they want their evenings to be protected for leisure? Do they need to prioritize weekends for hobbies?

Again, encourage to treat their studies as a job, which may encourage efficient use of available hours.

Any plan might be reasonable as long as there is some component of retrieval, interleaving, spacing, and some time for elaboration.

Question 10: Exercise - Given all that we have covered so far, consider the medical curriculum you are involved in. How does it harness evidence-based learning strategies? How could it be improved? Please send your responses to this email:-------

Tutor Guide

Some examples of effective aspects:

- *case base learning: encourages elaboration*
- *simulation: deliberate practice, feedback.*
- *mixing different components of curriculum longitudinally (e.g. clinical skills, medical content, professional competencies)*
- *using various modalities*

Some less-than-ideal examples

- *systems-based curriculum encourages massed practice and limits helpful spacing*
- *lectures and related cases delivered on same day - limits spacing.*

Open to any improvement strategies, this is to encourage learners to think critically about curriculum delivery, as many of them may have roles in education in the future. Some examples of improvements could include:

- *Randomize order of cases to encourage spacing*
- *Have more cases cover different health topics in the same case.*
- *Incorporate some interleaving of lecture material and exam material, getting away from pure system based curriculum, encourages spacing.*

Helpful resources

How to Study in Medical School.;
2016. https://www.youtube.com/watch?v=f06a8aHJK30

Gooding HC, Mann K, Armstrong E. Twelve tips for applying the science of learning to health professions education. *Medical Teacher*. 2017;39(1):26-31. doi:10.1080/0142159X.2016.1231913

- This is targeted at administrators but contains some useful information.