

EVIDENCE-BASED EVALUATION OF LEARNING TECHNIQUES

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Abstract:

In this review, I have studied and gone over some of the works done by cognitive scientists and researchers in this field where they rate some of the most used study techniques by students in terms of their efficiency.

Results have shown that techniques such as practice testing (active recall) and distributed practice (spaced repetition) have been rated as having high utility, whereas other methods like highlighting, re-reading and summarization have been rated as having low utility, despite them being widely utilized by students.

Strategies that have been given a high rating is due to their efficiency when it comes to different forms of learning and how research has shown that their effects are generalized across students and their abilities. Methods which have received a low rating is due to either lack of evidence for their effectiveness, or because the effects of these might just rely on individual capabilities, for instance summarization.

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1. Introduction:

What exactly is learning? Learning can be defined as the act of acquiring knowledge, or a certain set of skills in a manner so that the acquired knowledge or skill can be readily retrieved from memory whenever needed. (Brown, Make it Stick, 2014).

Within the education system, this translates to the fact that learning is not just the act of acquiring certain information and facts for the short term, but also how to consolidate a portion of that knowledge in one's long-term memory so that it is always readily accessible.

Learning is often misunderstood. It is an acquired skill and the most effective study techniques are often counterintuitive in the sense that the more effortful the process, the better the outcome. Learning is not supposed to be easy. It is in fact stronger and more durable when it requires effort. Learning that is easy is like writing in sand, here today and gone tomorrow. (Brown, Make it Stick, 2014).

We are poor judges of our own learning. Whenever learning feels hard, it does not feel productive and we are inclined towards using study techniques that might seem more fruitful, but we are unaware of the actual efficacy of them.

An important principle when it comes to learning is that the more effortful the learning process is, the better the retention and consolidation of that material. This is where the idea active versus

passive learning comes in as well. This encompasses the fact that the most fruitful techniques are the ones where the learner must actively engage with the course material. This results in deeper learning. This will be the essence and yardstick for how all the different techniques analyzed below are presented and assessed.

Learning is a life-long process, not confined to any age, individual or region.

After being a student and being deeply involved in the educational system for the past 16 years, which includes Pakistan and Norway, there is one crucial thing that I experienced to be lacking within the educational system. Students are comprehensively taught what to study and learn, but not how to study, or how to learn in the most efficient possible manner in order to attain maximum results when it comes to learning and understanding, within the shortest possible time.

What got me interested in this field of cognitive learning is tackling the sheer amount of work in medical school, which got me thinking that there must be ways of obtaining the maximum amount of knowledge in the most efficient manner possible. How can I reduce my studying hours while not compromising on the quality of my learning and ensuring that the material I learn gets processed into my long-term memory, such that it can be useful when treating patients, and not just for the purpose of acing exams.

The aim of my thesis is to provide a comprehensive, yet precise overview when it comes to the effectiveness of the most used study methods amongst students, as well as other strategies which according to evidence have proven to be valuable.

2. Method:

My project thesis is a non-systematic literature review.

One important contributing source I have studied is the research paper *“Improving Students’ Learning With Effective Learning Techniques: Promising Directions From Cognitive and Educational Psychology”* published in 2013 by Professor John Dunlosky (Department of Psychology, Kent State University) and his team, which is considered as one of the most extensive works done in this field. Professor Dunlosky and his team thoroughly reviewed around 400 research papers and experiments conducted in this field, summarized their findings and concluded with overall assessments of each learning technique. I have studied Dunlosky’s paper and summarized his conclusions below in the results section.

The way most of these studies have been conducted is that scientists divided students into different groups and assigned the same learning tasks to individuals in every group. In addition, these groups were also assigned a specific study technique they were supposed to utilize, let’s say group A would be the “highlighting group” whereas group B would be the “active recall” group. These students were then tested later, firstly on an immediate test, and then a few days later. Test scores were then plotted in order to observe and discuss the findings and hence, land on a conclusion.

The study techniques that I have chosen are highlighting, re-reading, active recall, distributed practice and summarization. The reason why I have chosen these specific study methods is simple; some of these techniques are the most widely used amongst students such as highlighting and re-reading, whereas others are rated as highly effective yet minimally utilized like active recall and distributed practice.

I also read and studied the book “Make it Stick: The Science of Successful Learning” written by Peter C Brown, Mark McDaniel and Henry Roediger III where cognitive scientists present key findings from numerous research papers and articles published on this topic.

In addition to this, I also made use of Google, an internet search engine to find some relevant pictures.

3. Results

This section contains reviews of five different study techniques. For each of those, I will briefly explain the technique itself before moving on to the advantages and disadvantages, and finally end each of these with an overall assessment of the efficacy of the study method.

3.1 Highlighting

Highlighting can be defined as using a marker to color specific pieces of information. When surveyed, most students report that they actively use highlighting while they read textbooks/notes, so that the highlighted material can be reviewed later. **(1)**

An experiment was conducted in 1974 by Robert Fowler and Anne Barker **(2)** where they divided a group of students into three groups. All the groups were given the same articles to read. The first group was the control group where the students were to simply read the text. The second group was the active highlighting group where they were asked to highlight the pieces of information that they considered to be important. The third group were the passive highlighters, where they simply read the text that was already highlighted by group two. All three groups were given one hour to study the articles and were tested one week later. The test results indicated that the active highlighters (group two) did not outperform the rest, however further analysis showed that the active highlighter performed slightly better on the questions that were related to the information that the students had highlighted (even though the overall exam performance was not

superior). Also, detailed investigation also implied that active highlighters retained the information better than the passive highlighter, who simply read the highlighted text.

Results on highlighting:

Advantages of highlighting:

As an explanation to these findings, researchers refer to a basic cognitive factor called “*the isolation effect*”. This can be defined as the fact that a distinct or unique item in a list is more easily remembered compared to the other item in the list which are not easily distinguishable from each other. An example of this would be a list with fruits; apple, melon, orange, banana, Tom Cruise, grapes and berries. The unique item in this list is the name Tom Cruise, which is unrelated to all the other members of the list and hence will be more easily remembered if a student is asked to memorize the list and then recall every item. In the same way, highlighted material tends to be more easily distinguishable. (3)

Disadvantages of highlighting:

There are two major conditions. Firstly, highlighting too much drastically reduces the isolation effect as lesser text is distinct from the rest, and secondly, this too much highlighting happens when students fail to understand what part of the text is the most important, and hence end up highlighting a lot. This means that less cognitive

processing is involved, and the learning process was passive.

Overall assessment:

Highlighting was rated as “low utility” by Professor Dunlosky and his team. It was also concluded that future research should be directed towards teaching students how to highlight effectively and make the process more active by highlighting as little as possible as this would also aid the isolation effect.

3.2 Re-reading

Re-reading a text is one of the most used study techniques according to multiple surveys, even amongst high-achieving students. (4). In a study conducted in 1968, students were divided into different groups where they read a text either once, twice, thrice or four times. Re-reading was massed, which means that the next reading took place immediately after the first round, so no intervals between the reading rounds. After 10 minutes, all the groups were tested, and results showed that test performance was proportional to the number of readings, until this effect declined for example there was no markable difference in the results between two readings versus four readings (5).

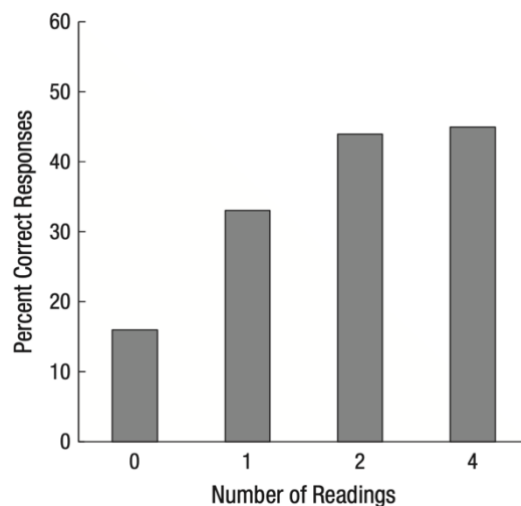


Figure 1. Mean percentage of correct answers based on the number of readings. Up til two readings, the number of correct answers increased in accordance with the readings, but this effect declined after two readings. The figure is taken from Professor Dunlosky's paper and the values are estimated from original figures in Rothkopf (1968).

Results:

Advantages of re-reading:

One basic hypothesis to explain these findings is the quantitative hypothesis proposed by Bromage & Mayer 1986 (6), which explains that re-reading increases the total amount of information that is encoded and hence this contributes to better results. Another important aspect that has been identified was by an experiment conducted in 2008 by Verkoeijen, Rikers, and Özsoy which concluded that the greater the interval between the initial reading and the re-reading, the better the results. So massed re-reading, where re-reading is done immediately after the first reading, is inferior to spaced re-reading. (7)

Another advantage is that this technique requires no training except for guiding students that re-reading with increasing intervals is better than massed reading. Re-reading is also more convenient and economical when it comes to time demands as compared to other techniques (below).

Disadvantages of re-reading:

The one major disadvantage of this method is the so-called “illusion of mastery”, also known as the Dunning-Kruger effect. This is defined as a cognitive bias where individuals with low abilities overestimate their competence. This is because while re-reading,

students get more and fluent in reading the text because of increased familiarization with the words and phrases in that text. Mastering the text is not the same as mastering the ideas behind that text as well. This tricks students into thinking that that they have developed a greater understanding of the material, whereas all that has happened is that have developed in a greater fluency in reading the text which does not impact how well one has understood the implications, applications and comprehension of the ideas that the text presents.

Overall assessment:

Re-reading was rated as having low utility. Even though re-reading with spaced intervals yielded better results compared to massed re-reading, the effects of this technique have been tested with recall-based memory measures only and hence its benefits with comprehension and understanding are not clear. In addition, re-reading is passive compared to other more efficient methods.

3.3 Summarization (Notetaking):

Summarization is another commonly used study technique amongst students. Often, students must learn a huge amount of material, and this requires students to really try to compress the that large amount of information into something more digestible. The main goal behind writing summaries and taking notes from books and lectures is to distinguish the important parts from the relatively unimportant ones.

(8)

One famous experiment was conducted in 1979 by Bretzing and Kulhavy, where student were divided into 5 groups and asked to read a 2000-word text in 30 minutes. (9)

Group A was the summarization group where students summarized each page into three lines after reading the page. Group B was the note-taking group where they took notes onto three lines while reading the text. Group C simply copied three lines that they thought were important from each page. Group D was the letter-search group where they noted down all the capitalized words from the text. Group E was the control group which simply read the text without any additional effort. After this, students were given two tests, an immediate one after 30 minutes, and the second test took place one week after the reading. In both the tests, students from Group A and B performed best and the results were as follows:

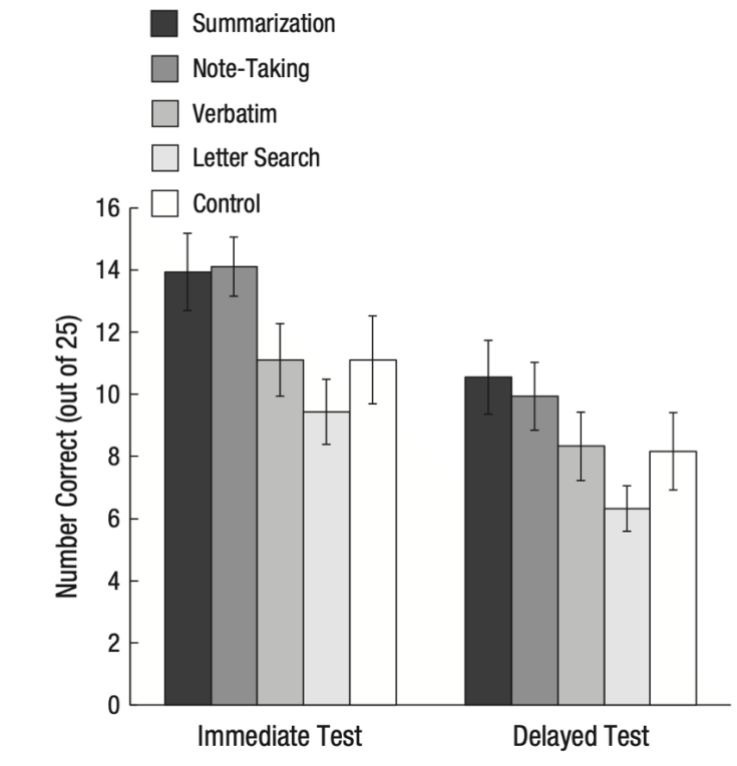


Figure 2; Average number of correct answers as a function of an immediate test and a delayed test. Bretzing and Kulhavy 1979.

What could be the possible explanation behind these findings? The experiment was designed in order to influence and manipulate the extent of cognitive processing and comprehension students went through while reading. Tasks such as locating the capitalized words and directly copying three important lines from the text involve much less information processing compared to summarization and note-taking which involve extracting the meaning behind the text, comprehending it and capturing it in one's own words.

So, how compelling is the evidence behind the efficacy of summarization and note-taking? This is one difficult question to

answer because summarization is not one individual study technique, but an entire family of techniques depending on how students take down summaries and notes. Numerous other studies have been conducted which demonstrate one fact for sure; the quality of the summaries and notes is essential in determining the learning benefit. Summarization is a skill which requires students to be able to identify what is important from what is unimportant. Studies have shown that students who write better summaries perform better on given tests as this reflects the fact that students have succeeded in extracting the higher level meaning of the text.

Results:

Advantages of summarization:

The benefits associated with summarization have been more commonly linked with elder students as the skill and ability to take notes, summarize and classify information as important or unimportant develops with time and practice. Younger students tend to write summaries of lower quality which involves a lesser use of their own words and the ability to recognize important information.

(10)

Many studies conducted have tested the effect of summarization on students' abilities to recall information through multiple choice questions. Benefits include improved comprehension of the text and increased higher-level processing. Studies have also shown that summarizing without the text in front of the students enhances

learning as well because students then must recall information from their memories. (More about this in the section about active recall below).

Disadvantages of summarization:

There have been numerous studies which have shown no major positive effects of summarization when it comes to testing comprehension and understanding. One such study was conducted in 1985 (12) where students who summarized did not show better performance than students who had only read the passage and were asked to answer questions related to that text one week later.

The quality of summaries has a great impact on its benefits. Students who are skilled at summarizing show better results than the ones who are not. Hence, the benefits associated with summarization show great individual variation.

Overall assessment:

If the aim is to utilize summarization as an efficient study method, then providing students with proper training on how to summarize is crucial. The question that now arises is whether it is worth spending time and resources on this when the benefits of summarization are robust and smaller compared to other useful techniques such as active recall and spaced repetition (section below). Considering all of this, summarization was rated as low utility. It may be useful for learners

who are already skilled at the task, but would otherwise require extensive training.

3.4 Practice testing (active recall):

Active recall is the act of retrieving target information from the brain through a variety of different methods such as flashcards, doing practice questions from textbooks, quizzes and solving problems while practically implementing the knowledge one has. The focus is on the word “practice” testing because this involves that students test themselves without the stakes being too high unlike an exam situation.

Testing has long been used as a tool to assess and measure learning instead of being used as a learning method itself. More than 100 years of research has produced evidence of the fact that retrieval enhances learning. For instance, in 2006 two groups of students were provided a text for initial study, and then one group was asked to restudy the text whilst the other group went through a practice test. One week later, both groups were tested again and the students who had done active recall by taking the test outperformed the students who restudied, 56% versus 42%. **(8)** This is only one of the numerous experiments that have been conducted, which prove the power of active recall as a learning tool within itself.

One common question that students might ask is that in order to be able to do practice questions and flashcards for example, you must surely learn the material first. So how can one practice active recall when you confront a piece of information for the first time? The answer to this question is simple. Many learners perceive active recall as a way of testing to see where one’s competence lies when exams

approach, instead of thinking of active recall as a way of learning itself. This can be explained through the generation effect. In a study in 1978, researchers showed that simply asking a subject to fill in a word's missing letters resulted in better memory of the word.

Consider a list of word pairs. For a pair like *foot-shoe*, those who studied the pair intact had lower subsequent recall than those who studied the pair from a clue as obvious as *foot-s—e*. This experiment was a demonstration of what researchers call the “generation effect”. The little effort required to generate the cued answer while studying the pairs strengthened memory of the target word tested later. (9) In other words, trying to solve a problem before being presented with the solution yields better than results than simply being given the answer the very first time as well.

Results:

Advantages of active recall:

Firstly, practice testing aids in highlighting one's strengths and weaknesses and this allows students to focus more on their weak points. This reduces the effect of “the mastery illusion” as students get a realistic insight and recalibrate how much material they have managed to understand and comprehend.

Secondly, this aids in consolidating information in one's long-term memory by creating new synaptic connections between the information that one knows from before, with the new information that is being learned. This is a direct effect of active recall as

proposed in a study in 2009. (10)

Thirdly, retrieval helps to interrupt the “forgetting curve” which in turn helps solidify the information that we have learned. I will elaborate more upon this in the subsection about distributed practice below.

Disadvantages of active recall:

The only gap that has been identified in the research related to practice testing is about learner’s personal and individual characteristics such as previous knowledge and recall ability. Other than that, even though active recall may seem counterintuitive in the sense that it requires effort and makes the process of studying more demanding, but as we have already established the premise above, the more effortful and active the learning process, the better the retention of the information that is being learned. So, this is actually a benefit and not a drawback.

Overall assessment:

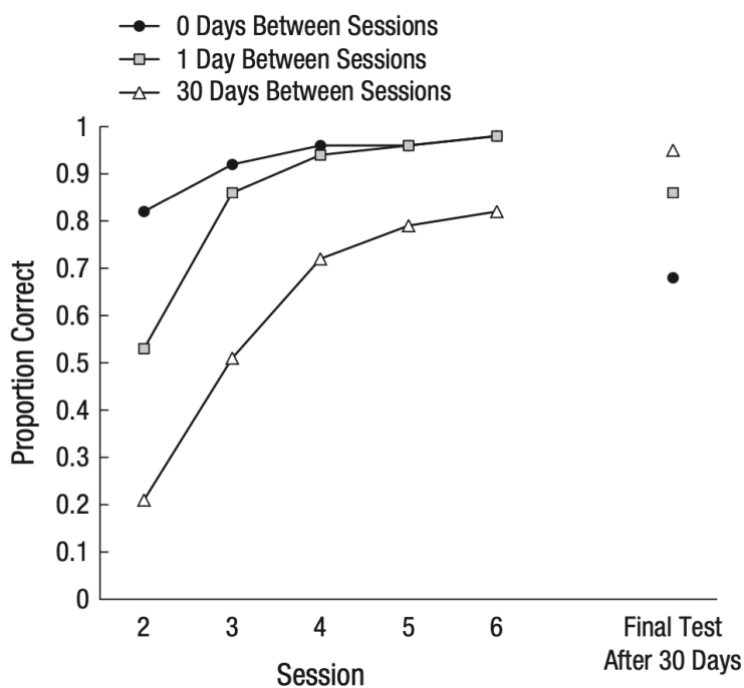
In accordance with over 100 years of research, practice testing has been rated as high utility, considering all the benefits that it has on learning and memory. The technique has broad applicability as it can be used in different forms like flashcards, quizzes, solving problems and questions and even explaining out loud to oneself or others. The technique requires almost no training and is also economical with respect to time demands.

3.5 Distributed practice (spaced repetition):

Distributed practice can be defined as the act of spacing act learning or revision sessions with increasing intervals. This is the opposite of massed practice, which is defined as repeated learning sessions within a short duration of time. Cramming before exams is an example of massed practice, whereas revising the course material multiple times in the span of a few weeks and even months is distributed practice. Numerous experiments have been conducted to explain the effect spaced repetition has. Let's have a short look at a classic study done in 1979. Three groups of students were given the same piece of information to learn in one learning session. After this initial learning session, there were five more learning sessions where each session started with a test and then students could revise the material and were given feedback. The first group had these five sessions with 0-day intervals, so a session every day after the initial session without any gaps between the days. The second group had these 5 sessions with 1-day intervals, so every other day. The third group had the session with 30-days intervals, so every new session took place 30 days after the previous one. The 0-day interval group had the best performances on the tests given at the start of every session, whereas the 30-day group was the one that forgot the most on every test. However, and this is where the results get interesting, another final test was taken 30 days after the last session for every group. The 0-day interval group had forgotten the most, whereas the 30-day interval

group remembered the most. So the intersession-forgetting was the highest for the 30-day group but the pattern was completely reversed when it came to the final test, hence proving that distributed practice aids long-term retention as opposed to cramming (0-day intervals).

The graph plotted below represents these findings. **(11)**

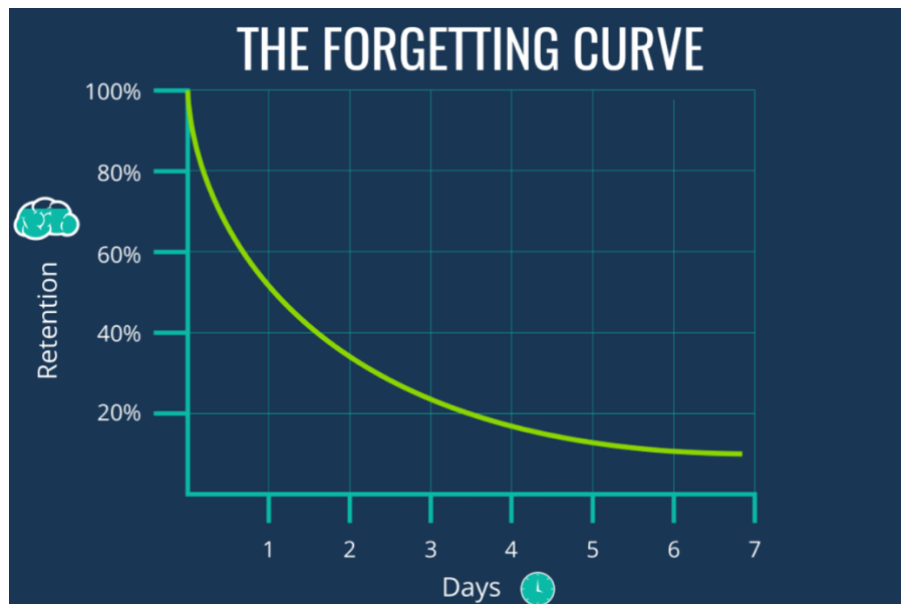


Results:

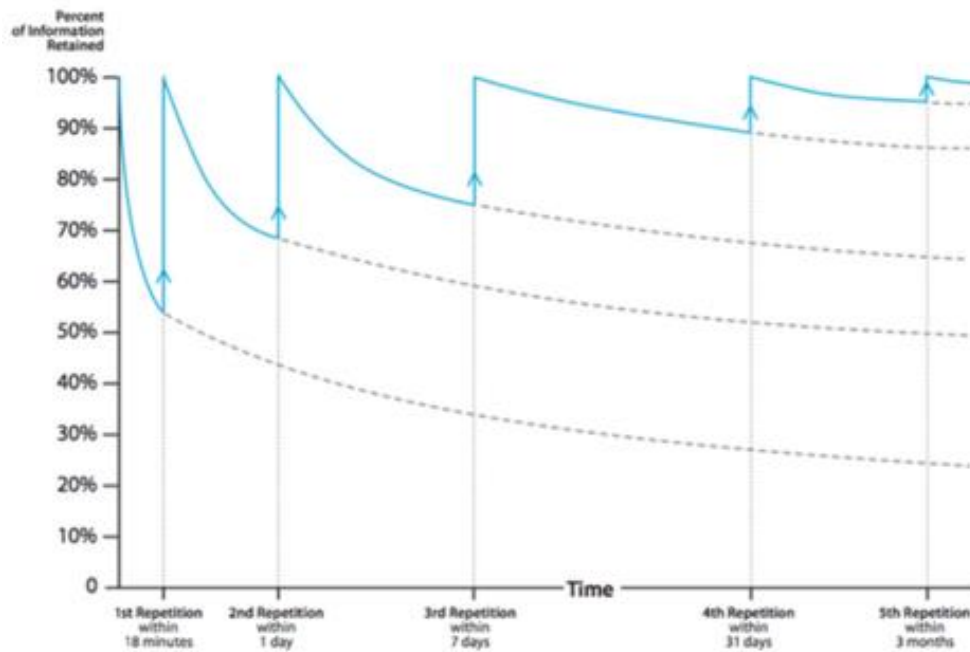
Advantages of distributed practice:

The major reason why distributed practice seems to work so well in long-term retention of information is because it disrupts a cognitive phenomenon called “The forgetting curve”, presented in 1885 by the renowned German psychologist, Hermann Ebbinghaus. The curve shows an exponential decline and demonstrates how quickly our brain

forgets information after first learning it. Our memory of that information is halved in a matter of a few days or weeks, unless we repeatedly revise that material. **(12)**



Spaced repetition helps consolidate information in our long-term memory because revising with increasing intervals takes our memory to the optimal learning point every time, and over time the curve transforms and goes from being exponential to relatively flat. This is how this can be depicted:



Disadvantages of distributed practice:

One possible downside of spaced repetition can be discussed in terms of its practical implementation considering how most students naturally study. The term “procrastination scallop” was proposed in 1991 by Professor Jack Michael (13) which explains that the time students spent on studying increases as the exam gets closer. This is a typical study pattern seen amongst students. This implies that students might not be naturally inclined towards distributed practice unless the situation encourages them to do so. This could be either because students do not yet fully understand the benefits of spaced repetition when it comes to learning and memorization, or simply because of other practical limitations.

Overall assessment:

Considering the high yielding benefits of spaced repetition, it is rated as having utility. It aids in the long-term retention of the material by interrupting Ebbinghaus' forgetting curve. For maximum results study session should be spaced in a fashion that allows some forgetting to take place as well, because this would then make the process of restudying more effortful instead of just mindless recitation of the material that happens when the intervals are too short, witnessed in massed practice (cramming).

4. Discussion:

In this literature review, I have studied and collected information from two main sources. Firstly, a research paper by Professor John Dunlosky where he and his team evaluated 400 other studies conducted on the most and least effective study techniques. Secondly, one of the most well-known books in the field of cognitive science and learning, “Make it Stick” by Peter. C Brown et.al. The goal of my thesis was to summarize the key findings from these sources where I included the most widely used study techniques amongst students; highlighting, re-reading, summarization, practice testing and distributed practice. The aim is to develop evidence-based recommendations for students and teachers about the efficacy of these study techniques. The main results have shown that highlighting, re-reading and summarization were rated as having low utility, whereas active recall (practice testing) and distributed practice (spaced repetition) were rated as having high utility.

How well established are the results and findings from these studies?

One weak point that I have noticed throughout this project is that there are still some areas which require more and in-depth investigation. One cannot be sure about how much these study techniques will benefit individual students in accordance with age, intellectual abilities and the level of prior knowledge. Secondly, I also think that the benefits of these study techniques need to be explored

more in terms of practical educational environments such as high-stake exams or performance tests so that each student who is being investigated does give it his/her best shot at actually learning the material and not just being “non-serious” about it. When the stakes are high, such as an exam, one can be at least sure of the fact that students have studied to the best of their abilities (at least in most cases). This could then possibly be a more secure measure of how well these study methods work. At the same time, the results are still valid to a great degree because we are not just relying on one study that has concluded this. Over 400 studies have been conducted which Dunlosky and his team have thoroughly studied. So this is definitely a strength. On top of this, the book “Make it Stick” is also an extensive source where the findings have shown the exact same conclusions when it comes to which methods are effective and which are ineffective.

Why do many students do not use effective study methods like active recall and spaced repetition? One possibility is the lack of awareness and knowledge amongst students. Teachers rarely focus on *how* to learn, whereas *what* to learn is mostly the focus. Part of the problem could be the fact that even teachers lack the necessary information about these different study techniques due to not enough focus on these in educational psychology. One possible implication of this knowledge is to guide students to use active recall and spaced repetition through organizing crash-courses and seminars about study

techniques. Secondly, teachers could also incorporate these strategies into their lessons in order to make the content and learning process more engaging and active for students. For instance, teachers could incorporate a mini-quiz after every 15-20 min into the lecture, so that the knowledge that students have consumed during the lecture is immediately tested. Students could also be handed question banks prior to lecture start, so that they can try and answer these questions during or after the lecture and test how much information they have absorbed and understood. Such minor changes could be essential in changing the way learning is viewed and improving outcomes of student learning and achievement.

I hope this literature review was able to give an in-depth, yet concise insight into different learning techniques and their relative efficacies. There are still areas which need more investigation as mentioned above, but along the with current information and results available, these researches have the potential to revolutionize our educational system, improve learning outcomes, and make the act of acquiring knowledge easy and fun.

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