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March 5, 2023

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Greetings Dr. Ward,

The report included with this letter is titled “The Best Teaching Method to Combat Knowledge Decay” and contains information about how severe forgetfulness is among college students within the U.S. as they travel through their academic career. In addition, information is also provided for why the spaced learning education method (the process of repeatedly learning and adding to concepts after set intervals of time) is the best method teachers can use to combat student forgetfulness. Additionally, information about competing teaching methods that also arise in the discussion of combating student forgetfulness is included.

While this topic wasn’t something I had a deep personal connection to at the beginning, I found myself increasingly interested in the concept of memory and how to combat forgetfulness as I went deeper and deeper into my research. I initially believed problem-based learning was the best method for retaining information. However, after delving deeper into the Ebbinghaus Forgetting Curve and into spaced learning, I found my position to be altered to be in favor of the spaced learning instructional method. One of the key points to look out for in the attached report is how each teaching method relates to the Ebbinghaus Forgetting Curve.

Thank you, Dr. Ward, for reading the attached report. I look forward to answering any questions or concerns you may have about the report at deverso1@my.chemeketa.edu or at 503-428-0952.

Best regards,

Duncan Everson

The Best Teaching Method to Combat Knowledge Decay

For

Professor Michael Ward

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By

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March 20, 2023

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Abstract

There is poor retention of knowledge among students within the U.S. traveling through their collegiate academic career. Higher level students' learnings are forgotten at a significant rate as they progress through time which leads to forgetting important information for their future endeavors. This can have drastic issues for incoming professionals in fields that hold the lives of individuals in the balance such as medicine or engineering. The poor memory retention needs to be solved in a timely manner in order to gain the leeway to offer students more diverse knowledge that can be even more beneficial for their work and their careers.

Lecture learning is the most common teaching method in U.S. higher education. This education method is not as effective as desired for ensuring students retain information over extended periods of time. Teachers that teach using lectures often claim that students fail to retain information taught to them months prior, which leads to them seeking out new methods to increase the students' knowledge retention.

Many educators and researchers alike seek to learn what the best teaching method for ensuring long-term knowledge retention is. The three most popular and commonly researched alternatives to lecture learning are spaced learning, problem-based learning, and inquiry-based learning. Spaced learning exists as the best option for ensuring knowledge retention because it increases the time it takes for knowledge to decay and increases the amount of knowledge a student holds after the majority of the knowledge decay has occurred.

Introduction

There is poor retention of information among students within the U.S. as they travel through their collegiate academic career. In a scholarly article written by Angela Dills and her colleagues titled “Knowledge Decay Between Semesters,” Dills reports that “we appear to find evidence of a summer learning loss [between terms], also known as knowledge decay, at the college level” (Dills, 19). Many U.S. college students struggle to remember information that has been taught to them over extended periods of time, which can have long lasting consequences especially in careers where the lives of people hang in the balance.

Educators across the U.S. have been involved in the discussion regarding the best teaching methods to combat the knowledge decay that exists in higher level education. Some of the more popular options that both high school and college educators have been gravitating toward are problem-based learning, inquiry-based learning, and spaced learning. Problem based learning is the process of attributing information to real world problems as corresponding solutions. Inquiry based learning entails students answering their own questions via hands on experiences and then presenting their questions and answers to their peers. Spaced learning involves repeatedly learning and adding to concepts after set intervals of time.

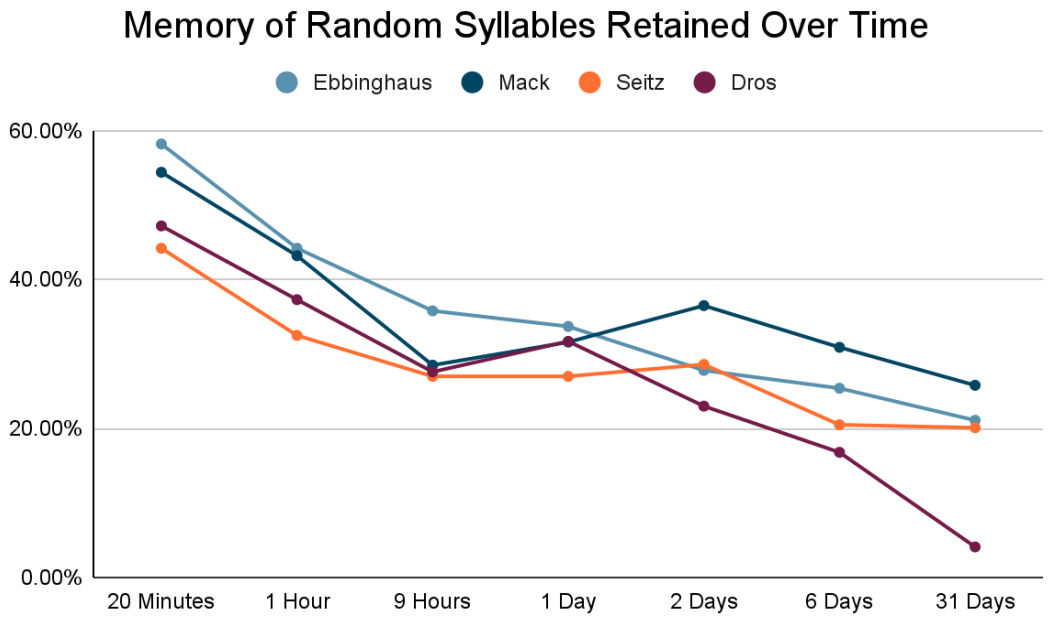
In order to best combat knowledge decay among students traveling through their academic careers, spaced learning should be utilized by educators to ensure and establish both long term and short term memory retention. While all aforementioned teaching methods do show promise in increasing student knowledge retention, the best teaching method to decrease knowledge decay in the short and long term is spaced learning.

Knowledge Decay

Ebbinghaus Forgetting Curve

The Ebbinghaus Forgetting Curve is a well studied phenomenon in psychology dating back to 1913, when Hermann Ebbinghaus tested his own memory retention over time using nonsense syllables. Learning a subject is often thought of as something that individuals only need to do for a set period of time before moving onto new topics; however, it is a reality that students must continuously reintegrate old knowledge into their mind to keep it from decaying just as the Ebbinghaus Forgetting Curve suggests. Figure 1 showcases recreations of the forgetting curve based on the results of different individuals’ experiments to gauge how much information is retained as time passes after the initial learning:

Figure 1



Source: Murre, Jaap, and Joeri Dros. "Replication and Analysis of Ebbinghaus' Forgetting Curve." *PloS one*. 6 July. 2015, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4492928/

This curve is applicable to students moving through their academic careers in U.S. Colleges and Universities. According to a study by Diane Bunce and her colleagues, titled "Decay of Student Knowledge in Chemistry," some students attending a lecture based learning environment within schools in the mid-atlantic region of the U.S. experience a significant loss of knowledge over time (Bunce, et al. 7). The rate of the lost knowledge can be modeled using the Ebbinghaus Forgetting Curve. This knowledge decay showcases that lecture learning is not the best learning method for students to retain knowledge they have learned.

The Failure of Lecture Learning

Lecture learning focuses on having the instructor speak in front of the class while the students take in the information that is conveyed. Nearly always in higher education, students try to take notes in order to aid their memory of the concept that they are learning. Lecture learning is the most common educational practice within U.S. colleges and universities. Once the students complete a course they will move forward to begin learning the next batch of information that is required of them. The main issue with lecture learning is that teachers often report that students forget the content that they should already know as a prerequisite for being in their current course.

The Ebbinghaus Forgetting Curve is a suitable model for the rate of forgetting that students undergo. According to the forgetting curve, students will continuously forget content that they have learned as time passes. This holds true for lecture learning as well. Within a study conducted and written about by Diane Bunce and her colleagues, titled "Decay of Student Knowledge in Chemistry," Mark Wheeler's report is paraphrased by Bunce who says that "undergraduates experience extinction of learning (decay of knowledge) within 48 h[ours] of a testing situation" (Bunce et al., 1). Based on this understanding, lecture learning cannot be relied upon to successfully ensure student retention of information.

Alternatives to Lecture Learning

Spaced Learning

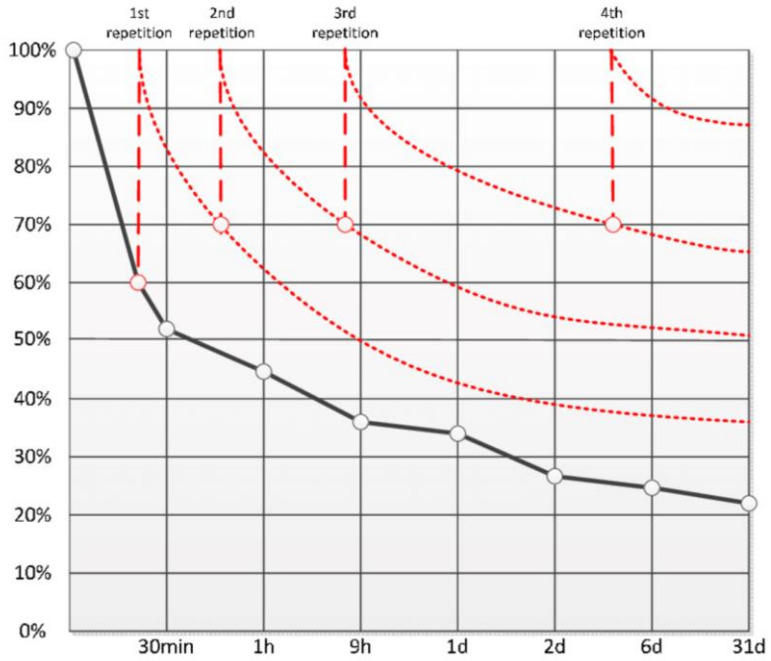
Spaced learning is a process that involves repeatedly learning and adding to concepts after set intervals over varying periods of time. Spaced learning can be thought of as deliberate repetitions designed to reinforce and expand upon information in the mind. Spaced learning has grown in popularity as time has progressed and has undergone large amounts of research in an attempt to discern its effectiveness as a teaching tool.

Spaced learning can be employed as a short term method as well as a long term method. A short term spaced learning method might look like class topic reviews three days after the initial learning of the topic. Spaced learning employed over a longer period of time could look like sending out refreshers for information learned months prior and then implementing extra credit quizzes. Ultimately, both lengths of using spaced learning have demonstrated positive results for students' knowledge retention.

The short term benefits of spaced learning center around the creation of new Ebbinghaus Forgetting Curves. Spaced learning creates new Forgetting Curves due to the fact that the information is being reintroduced, allowing the information to be utilized by the student for a longer period of time than if no reintroduction occurred. Additionally the curve also extends for every reintroduction of knowledge. Continuous modification of the Forgetting Curve increases the time it takes for knowledge to decay with each new curve. Another difference in the Ebbinghaus Forgetting Curve that occurs when spaced learning is used is that the curve converges at a higher and higher percentage of knowledge retained after the majority of the decay occurs. An example of this can be seen in Figure 2, where the a graph of the Ebbinghaus Forgetting Curve is shown along with the modifications that occur from the reintroduction of the initial information learned after set periods of time:

Figure 2

Memory of Syllables Retained Over Time With Repetitions of Learning



Source: Schimanke, Florian, et al. "What to Learn Next? Content Selection Support in Mobile Game-Based Learning." E-LEARN World Conference on E-Learning, Las Vegas, NV, USA, October 2013. *ResearchGate*. https://www.researchgate.net/figure/Alteration-of-the-forgetting-curve-through-repetition-according-to-Ebbinghaus-1885-and_fig1_268130455

While Schimanke's graph showcases how knowledge retention can be increased by using spaced learning in the short term, a long-term spaced learning approach also yields great results as well. In a study conducted by Price Kerfoot and his colleagues, Kerfoot reports about an experiment conducted over the span of a year using a batch of students studying the same thing. Kerfoot says that "[t]his randomi[z]ed controlled trial demonstrates that spaced education consisting of case scenarios and clinical questions distributed weekly via e-mail can significantly improve students' retention of medical knowledge" (Kerfoot, et al. 7).

Problem-based learning

One potential teaching method that has been discussed as a viable option for higher education instructors is problem-based learning (the process of attributing information to real world problems as corresponding solutions), which has demonstrated positive results over traditional lecturing methods in terms of knowledge retention of medical information (Beers and Bowden, 4). Problem-based learning is a method that centers on how the learner perceives the information.

An example of problem-based learning would have business students practice pitching their own ideas for business plans that would solve a societal problem. Another example of what a problem-based learning environment could entail is having a focus on completing case studies related to real world situations and events.

Problem-based learning does not benefit knowledge retention as much as spaced learning. Within a study conducted by Geri Beers and Susan Bowden, they reported, “For this study, we concluded that PBL did affect the long-term retention of knowledge of diabetes content (Beers and Bowden, 3). This increase in knowledge retention can be seen as stretching out the Ebbinghaus Forgetting Curve. However, while problem-based learning modifies the forgetting curve by increasing the time it takes for knowledge to be lost, no further modification occurs after the point of initial learning. The knowledge will still deteriorate faster and at an increased rate than if spaced learning was used instead over an extended period of time.

Inquiry-based learning

Another potential teaching method that has been talked about as being suitable to increase memory retention is inquiry-based learning. Marcia Linn describes inquiry-based learning as “the intentional process of diagnosing problems, critiquing experiments, and distinguishing alternatives, planning investigations, researching for information, constructing models, debating with peers and forming arguments” (Schmid and Bogner, 3). Inquiry-based learning entails students seeking answers to their own questions by utilizing research and direct observation under an educator’s guiding hand. Once the information has been acquired by the student, they then evaluate what they have learned to discern what still needs to be learned or elaborated upon. Inquiry-based learning is a very active and involved educational process.

An example of inquiry-based learning would be having students perform a lab so that they can get firsthand experience of the event. Another example of an inquiry-based learning environment might be having the students complete hypothesis based research projects, and then having the students share them with their peers.

Similarly to problem-based learning, Inquiry-based learning has shown positive effects in memory retention. In a report written by Sarah Schmid and Franz Bogner, it is stated, “Although our inquiry lesson lasted just for half a day, significant learning outcomes and long-term effects on content learning were achieved” (Schmid and Bogner, 12). While inquiry-based learning does increase memory retention in students, it does not continuously modify the forgetting curve as the spaced learning method does. Just like problem-based learning, inquiry-based learning can be seen as stretching out the initial forgetting curve instead of continuously making new forgetting curves that converge at higher and higher percentages of knowledge retained. Just like with problem-based learning, the knowledge will still deteriorate faster and at an increased rate than if spaced learning was used instead over an extended period of time.

Conclusion

Summary of Findings

Students forget a large amount of information taught to them through a pure lecture learning environment. Lecture learning follows the curve that is found in the Ebbinghaus Forgetting Curve. Educators and researchers have been investigating and discussing alternatives to lecture learning that showcase better results for memory retention than lecture learning does.

The three teaching methods that are the most popular among those within the educators' and researchers' discussion are spaced learning, problem-based learning, and inquiry-based learning. Spaced learning exists as the best alternative to lecture learning due to the fact that it continuously creates new and improved Ebbinghaus forgetting curves. Every time a spaced learning repetition occurs a new forgetting curve is created which has the aspects of being flatter than the previous curve and of converging at a higher percentage than the previous curve. This translates to having a decreased rate of decay of knowledge loss and a higher final amount of retained knowledge after the majority of the decay occurs. Problem-based learning and inquiry-based learning do not create new forgetting curves which means their benefits only exist within the shifting of the initial forgetting curve. The two have lower initial rates of decay and a higher initial quantity of retained knowledge after the majority of the decay occurs than spaced learning's initial curve. However, as time progresses, spaced learning will create a lower rate of knowledge decay and will have a higher quantity of retained knowledge after the majority of the decay occurs than either of the other two alternatives to lecture learning.

Recommendations

In terms of knowledge retention, the spaced learning method exists as the best. However, knowledge retention is not the only thing teachers must take into consideration when adopting an instructional method. Things such as student motivation, student satisfaction, and student comprehension are all important to the learning process. So far, there exists no single best all around teaching method. The best thing for educators to do is to try to merge together the best aspects of multiple teaching methods into a unique style that fits their content. In addition to crafting their own curriculum, educators may try to offer study plans to their students that focus around a spaced learning approach. This may look like a schedule of restudying prior content that would help to ensure higher knowledge retention. Alternatively, educators could offer a third party resource for students to utilize if they want to make sure they review and reintroduce information that they should know by now as a prerequisite. Further study could be conducted to determine what combinations of teaching methods work well together and produce desirable results.

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