

Improving the Recall of Factual Knowledge Based on Experiments Conducted by Herman Ebbinghaus

Torsten Palm

Binary Tree AB, Balinge, Sweden

torsten.palm@gmail.com

Abstract: Learning factual information is an activity that most individuals have engaged in during their schooling, at university, or in specific courses. It is commonly stated that one "absorbs" facts, with the intention of retaining the learned material over time. According to memory psychologist Hermann Ebbinghaus, a specific pattern must be followed to prevent the forgetting of learned material. Ebbinghaus, H. (1885) *Über das Gedächtnis zur Experimentellen Psychologie* Verlag von Duncker & Humblot, Leipzig. The article outlines the approach necessary to maximize retention. When a considerable number of individuals adhere to Ebbinghaus's pattern, it results in a group whose memory of the learned material improves from a lower level to a significantly higher one. If this group comprises employees within an organization, it leads to what is known as a "knowledge gain" for the organization, thereby enhancing the overall quality of its collective knowledge. This pertains to the concept of organizational memory—the total knowledge residing within an organization. In the article by Walsh J.P. and Ungson G.R. (1991), titled "Organizational Memory," published in the *Academy of Management Review*, the authors highlight the critical importance of effectively managing and leveraging an organization's accumulated knowledge, thereby elevating the practice of knowledge management.

Keywords: Ebbinghaus, Forgetting curve, Factual knowledge, Repetition, Memory certification

1. Introduction

In a previous article written by Palm, T and Fahlgren, J (2016) *Academic knowledge control with E-exams and reflections on the Ebbinghaus forgetting curve*, Department of Informatics and Media, Uppsala University, the theories put forward by the German memory researcher at the end of the 19th century were considered. The results of his experiments provide a reason to question how current knowledge checks are carried out in universities and colleges, especially with an emphasis on so-called factual knowledge. There is therefore reason to consider the current knowledge control of so-called factual knowledge in our higher education institutions and investigate whether better alternatives are available. This article aims to highlight that this is the case.

2. Fifty Years of Exam Tradition

For more than 50 years, written examinations at Swedish universities and colleges have been conducted in much the same way. A written exam is when the written test for students takes place at the end of a course with a duration of between five and ten weeks. The written exam at the end of the course often consists of a number of questions or problems to be answered. Examinees have a set amount of time to answer questions or solve given problems. It is now common for other types of examinations and compulsory ones to occur during the course. These may include seminars, laboratory work and assignments. Short written examinations are also used. In summary, there are a number of different forms of examination.

In connection with the university entrance examination or the theory test for driving licences, the tests are designed with so-called multiple choice questions. Such a question structure can, if desired, result in instantaneous correction and reporting of results.

At present, so-called 'hall exams' are usually conducted by having students answer questions and problems on paper. The exam questions answered on paper are collected and handed over to the relevant teachers for marking. Students who fail the exam are given a second opportunity to take a re-exam. This takes place a few weeks after the first exam or at a later date, for example at the end of the semester. It is usually said that the chances of 'passing' the re-exam are greater than the chances of passing the first regular exam. One probably has in mind here that when the student is to take the re-exam, the student will repeat the course content once again. It is said that 'Repetition is the mother of all learning'.

3. Ebbinghaus Forgetting Curve And Views on its Consequences

3.1 Memory Research late 19th Century

At the end of the 19th century, the German psychologist Hermann Ebbinghaus reported, by conducting experiments on himself, how we remember and forget learnt material. He was able to show that if we check how much we remember over the course of a week, we forget the most in the first few days, and by the end of

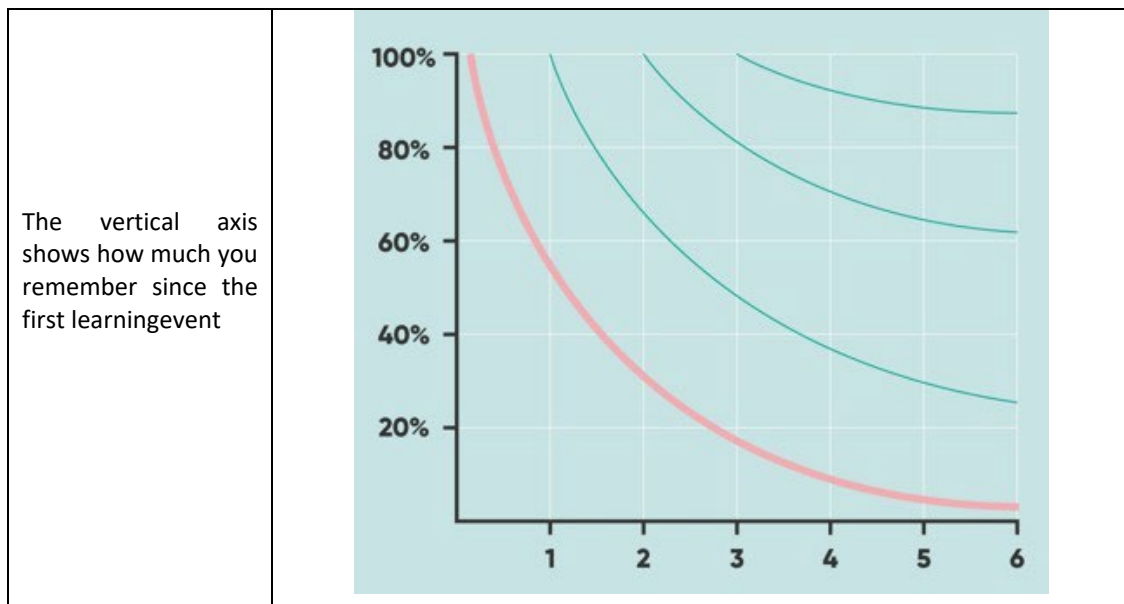
the week we remember about 20% of what we have learnt. If the results are presented in a diagram, the memory curve falls steeply during the first few days of the week and flattens out at the end of the week. The falling curve is known as the 'forgetting curve' and is a well-known phenomenon.

In the discussion that follows, exact values are given in per cent, such as 20% and 80%. These values are provisional. Taking each individual's approach to memory means that no two individuals are alike. It is likely that the values will be more accurate when comparing larger groups, where average values can be discussed. In this case, there is no extensive experimental material to draw on. Rather, this report should be seen as a suggestion on how to proceed with investigating the results for a larger group of students.

Although much theory has been developed in the field of memory research since Ebbinghaus' findings were reported, he presented for the first time an understanding of how people remember and forget learnt material. He showed that unless the learnt material was repeated a certain number of times according to a set time pattern, only a small part of the original material was remembered, as mentioned earlier. In the 20th century, similar experiments were carried out and found that Ebbinghaus's discovery was correct and that it was primarily a matter of factual knowledge.

Even today, at the beginning of the 21st century, the forgetting curve is still referred to in the context of memory research experiments.

In Figure 1 below, the graph represents the so-called forgetting curve. The vertical axis indicates how much you remember. The higher up the vertical axis, the more you remember. The horizontal axis shows the number of days elapsed from the first knowledge check and when the other knowledge checks take place.



Number of days since the first learning event started

Figure 1: Ebbinghaus forgetting curve. (Herman Ebbinghaus 1885)

If you start from day 0 on the horizontal axis, i.e. the day you take your regular written exam, you remember 'everything'. After just one day, day 1 on the horizontal axis, you have forgotten almost half. The curve starting from day 0 passes day 1 and has dropped to almost 50%. After six days, the curve from the first knowledge check has dropped considerably. You have forgotten most of it and remember about 20%. If you re-peat the test after one day, day 1, i.e. you rehearse first so that you know 'everything' before the second knowledge check and complete it, you remember more after 6 days compared to the first time. If you do the second, third and fourth knowledge checks, see Figure 1, you remember most of the facts, about 80%. The graph in Figure 1 represents an approximate picture of the forgetting curve. In addition to the first written ordinary exam, three knowledge checks follow. Some people mention both four and five knowledge checks in addition to the ordinary exam. Some of us remember more, while others do not remember as much. There are different views on how close in time the retests should take place.

But we still get an idea from the example, by looking at the diagram, of the shortcoming of writing only once and the advantage of writing several times in a row on the same subject. This means that if we take Ebbinghaus'

130-year-old results into our time while keeping in mind the way academic written exams are conducted in the present. This means that the knowledge material the student has 'learnt' and 'tested' during 3 years of study, the student remembers after a short time only the knowledge content corresponding to half a year of study.

We assume that the student in question has not benefited from having taken multiple exams on the same material. The remaining 2 1/2 years of 3 years of study have been forgotten. A very poor investment of time and money.

The 20% figure in paragraph 2.1 above and the 80% figure at the end of paragraph 5.2 below are taken from the data that can be interpreted from tables and graphs that report or refer to the forgetting experiment originally conducted by Ebbinghaus. In addition, the extent to which people remember and forget differs from one individual to another.

3.2 Repetition is Beneficial

As mentioned above, Ebbinghaus showed that if you repeat the learnt material about three times and do it after a certain time pattern, you remember knowledge equivalent to 2 1/2 years of study. A considerable improvement! According to Ebbinghaus, the time pattern for the first three repetitions should be relatively close in time, already during the first week, counting from the first knowledge check, the traditional written exam. Other accounts of the forgetting curve and how to reduce its steepness state that the four repetitions can take place over a couple of weeks. Wolf, Gary (2012) describes in the link, <http://quantifiedself.com/2012/06/spaced-repetition-and-learning/>, how to use different methods to reduce the forgetting curve and make learning more effective. Wolf's introduction refers to Ebbinghaus' discovery of 'the forgetting curve' and 'the spacing effect'. With 'the spacing effect' means that it is more beneficial to break up the learning of a material with breaks in between. Gipple, Jimi Gipple (2015), ICSlearningGROUP, refers to Ebbinghaus in his article 'eLearning: Overcoming the Forgetting Curve,

The findings of Gary Wolf and Jimi Gipple recognise that forgetfulness in education is a barrier to long-term learning. Mr Wolf has developed tools to help overcome forgetting that increases over time. It is therefore of great interest to know how memory research today views Ebbinghaus' discovery and what implications it may have for the knowledge control of theory theory at our universities.

In my opinion, the way in which knowledge verification is carried out in academic institutions will determine how much students remember after completing their studies. It is not difficult to see which of the students an employer would prefer to employ, the one who remembers 80% or the one who remembers 20% of the knowledge material covered during the programme. We assume that both students have been assessed as equivalent in other respects.

3.3 What can we do?

By drawing attention to the steep fall of the forgetting curve after learning and how to counteract a large part of forgetting, universities and colleges are faced with several choices. Therefore, to move the discussion forward, the concept of memory certification is introduced, which means that a student can report how much of the learnt material is retained over time. Should individual students be voluntarily memory certified up to the 80% memory level or should the whole institution be memory certified? If the institution chooses to let the individual student decide whether they want to be memory certified in addition to the existing procedures for knowledge control, it means an addition to the current procedures for written examination. Students who choose to recall certification in addition to the existing procedures are offered three knowledge checks distributed appropriately over time. The memory checks or exams, which follow the first written exam, must be changed to be more administratively manageable than the first one. If the management of the subsequent knowledge checks is not changed, at least three times more resources will be required to conduct a knowledge check with certification up to the 80% level, taking into account the prevention of forgetting the learnt course content. Instead of marking the second and third knowledge checks in the traditional way, it is advisable to move to so-called multiple choice exams in the form of e-exams. Feedback to the student is instantaneous and the cost of administration is significantly reduced compared to the traditional approach of 'marking by hand'. If the whole institution decides to move to memory certification, it requires preparatory work, mostly in the form of producing multiple choice questions with answer options.

3.4 Enhancing Long-Term Memory - a Competitive Advantage

We may thus prefer to allow individuals to choose to recertify themselves for 80% retention over time in addition to the current option of a written exam and 20% retention over time. We, as noted earlier, can also choose to

have the whole institution memory certified with the equivalent of 80% retention of knowledge over time. The choice depends very much on how much memory certification is perceived as a competitive tool in academic undergraduate education vis-à-vis other universities and employers.

4. Traditional or Memory-Certified Knowledge Check

4.1 Why Change?

As mentioned earlier, activities in higher education have traditionally been carried out in the same way decade after decade. Admittedly, several changes have been introduced with the aim of improving and streamlining teaching. But to a large extent, many teaching activities are similar across the ages. In the past, it was common in Sweden for a whole 20-week course to be examined at the end of the semester. Now it is more common for the semester to be divided into shorter courses, which are examined at the end of the course, a way of dramatising studies and increasing the possibility of more courses being completed. The prevailing perception of knowledge control at higher education institutions can be seen as relatively similar over time. Something along the lines of students 'emptying out' what they have 'learnt' during the course when they sit an exam. Instead, the organiser of the assessment should aim to ensure that a student retains as much of the learning material as possible for as long as possible.

4.2 Why TV Adverts?

On the vast majority of TV channels, the regular programme is frequently interrupted by commercials. The same adverts are repeated to remind viewers of the brand and product. Why is the same thing repeated over and over again? The intention, of course, is to make us remember and not forget the product in question, or for the Ebbinghaus forgetting curve not to drop steeply, but instead to stay in the upper 80%.

5. Discussion and Reflection on Written Exams in our Academic Institutions in the Light of the Results of the Ebbinghaus Experiment

5.1 Can the Current Written Exam be Streamlined?

The question is whether the results of Ebbinghaus' discovery have been overlooked out of tradition and habit, and whether we have therefore been content to check learnt knowledge on only one occasion. It does not seem entirely convincing that the current knowledge control in our academic institutions is based on science. The intention to investigate and clarify how to implement a more effective knowledge control and to strive to allow the student to retain most of the learned knowledge cannot be emphasised enough. If the approach to knowledge control is appropriately modified, the efficiency of retained knowledge over time would be greatly improved.

5.2 Questions Emphasising Increased Scientifically in Written Exams Should be discussed

- How can the academic knowledge management process, including preparation, implementation and follow-up, be improved and made more efficient by moving away from current analogue procedures to digital ones?
- What theories of learning psychology support the view that existing approaches to academic writing assessment are adequate and promote long-term learning?
- If the statement in point 2 cannot be fulfilled, what theories of learning psychology support the view that existing approaches to academic written knowledge assessment should be changed and improved with an emphasis on long-term retention of what has been learnt?

6. A Proposal for a First Comparative Experiment Between the old and the new

Of further interest is to have a larger group of students, 100 students. The group is randomly divided into two parts, where one group follows the traditional way of examining by doing a regular exam and those who 'do not pass' do a re-exam after 14 days. The other group takes a regular written exam on the course. The day after the regular exam is taken, the second group of students takes a first re-test one day after the regular exam, where the exam questions are presented in the form of multiple-choice questions in the same way as in the university entrance exam. Thereafter, two more re-exams with multiple choice questions are given a few days apart. The last and fourth re-tests are given in the traditional form, i.e. students answer in writing. The number of days needed for the latter option is proposed to be 5 days. The fourth re-examination is proposed to be the same as the re-examination of the regular written examination. To facilitate management, a digital e-examination system is used, where all management including planning, execution and follow-up is done digitally. One month later,

the entire student group, 100 students, undergoes a new written multiple-choice exam, where it is possible to compare the results.

7. Impact of the Introduction of the new Approach

With the proposed approach, each course is extended by one week, i.e. each 5-week course is extended to a 6-week course. For each new 6-week course, one week is lost. Compared to the number of 5-week courses in an academic year, which includes 8 5-week courses, moving to 6-week courses in an academic year, which in this case includes 40 weeks, results in the loss of one 5-week course. In the academic year of the new proposal, the knowledge content is reduced by the equivalent of 5 weeks, while in return, as shown above, students remember significantly more than they would have done under the old approach. More specifically, the student remembers 20% of the knowledge material from 8×5 week courses, i.e. $0.20 \times 8 \times 5 = 8$ weeks of knowledge material. Knowledge material corresponding to 40 weeks of study has been reduced to 8 weeks of study. If, on the other hand, the student gets a memory certification, the corresponding memory material is $0.8 \times 6.7 \times 6 = 32.16 \approx 32$ weeks of knowledge material. The comparison between 8 and 32 weeks of study is significant.

However, there is every reason to consider the major difference in knowledge acquisition, namely 24 weeks of knowledge material. Even if we allow 20% and 80% to approach each other, say 30% and 70%, the difference becomes very large.

There is therefore a strong case for exploring the possibility of memory certification of knowledge tests in higher education institutions. Academic institutions that are the first to implement this approach will have a particularly strong competitive advantage.

References

- Ebbinghaus, H. (1885) *Über das Gedächtnis zur Experimentellen Psychologie* Verlag von Duncker & Humblot, Leipzig.
- Gipple, Jimi Gipple (2015), ICSlearningGROUP.
- Palm, T and Fahlgren, J (2016) Academic knowledge control with E-exams and reflections on the Ebbinghaus forgetting curve, Department of Informatics and Media, Uppsala University.
- Walsh J P & Ungson G R (1991) Organizational memory. *Academy of management reviews*
- Wolf, G. (2012) *QS Primer: Spaced Repetition and Learning*.