Editorial

Health simulation: history and applied cognitive concepts

Simulação em saúde: história e conceitos cognitivos aplicados

Danielle Rachel dos Santos Carvalho[1]
Nathalia de Moraes Lébeis Nery[2]
Thiago Santos Martins[3]
Dario Cecilio-Fernandes[4]

[1]Corresponding author. Universidade Estadual de Campinas (Campinas). São Paulo, Brazil. drss.farmaceutica@gmail.com
[2]Universidade Estadual de Campinas (Campinas). Faculdade São Leopoldo Mandic (Araras). São Paulo, Brazil. nathalialebeis@yahoo.com.br
[3-4]Universidade Estadual de Campinas (Campinas). São Paulo, Brazil. santosth@unicamp.br, dario.fernandes@gmail.com

Introduction

Simulation has been used as an educational tool for a long time. However, despite the increased use in different fields, such as aviation and healthcare, its use is often intuitive. In this article, we will discuss the concept of simulation with a brief historical review and introduce evidence-based concepts that have been shown to improve learning. As the use of simulation is extensive, including different fields, we will mainly focus on the healthcare literature.

In this article, we will use the concept of simulation proposed by Gaba: "Simulation is a technique, not a technology, to replace or amplify real experiences with guided experiences that evoke or replicate substantial aspects of the real world in a fully interactive manner."[1] Gaba's[1] concept brings two relevant aspects of simulation: 1) the lack of necessity to have a technology associated; and 2) the importance of an immersing environment, allowing an experience closer to reality.

Training in a real clinical environment lacks equal opportunity for all students to practice the proposed skills and repeat as many times as necessary to acquire the trained skills[2] since it depends on the patients and places they are. In the simulation environment, however, it is possible to practice a specific skill as many times as necessary to reach proficiency without worrying about disturbing patient care. Also, different situations with different levels of complexity can be offered, according to the learning objectives and stage of the student's education. Complexity refers to the difficulty and depth required in the clinical case addressed[3], depending on the learners' level. For example, a cardiac arrest scenario is considered highly complex for a sixth-year medical student because it requires integrating knowledge, skills, and attitudes than, for example, a scenario of administration of drugs via subcutaneous, considered of low complexity. For an emergency physician, however, a scenario of cardiac arrest is considered with low complexity.

The ethical aspects and risks of teaching in the real environment have also been questioned without any training. Simulation allows students to experience authentic problems in a safe and pedagogical environment, having the opportunity

How to cite this article: Carvalho DRS, Nery NML, Martins TS, Cecilio-Fernandes D. Health simulation: history and applied cognitive concepts. J Health Educ. 2021;5(1):xx-xx. http://dx.doi.org/10.17267/2594-7907ijhe.v5i1.3889

to practice their skills in a simulated way before performing them on real patients.[4,5] That is, during the simulation, students experience challenging situations in a safe and psychologically adequate environment, where mistakes are allowed, as one of the purposes is to learn from mistakes, since there is no harm to patients and professionals.[6]

Through simulation, it is possible to carry out health education and training, both in technical skills and patient management and in skills related to patient safety and teamwork.[7] In other words, the use of simulation allows the creation of activities according to the needs of the participants, through experiences, followed by a moment of guided reflection on the participant's performance in the activity, known as debriefing, which has a direct impact on the theoretical knowledge of the student and their professional practice.[8-10]

History of simulation training

The use of simulation in healthcare training is old, with reports of anatomical models dated by ancient times and the use of animals in surgical skills training.[11] The use of mannequins had existed only for half a century when they began to be used for resuscitation training.[12,13] Modern simulation was initiated by a toy manufacturer, the Norwegian Asmund Laerdal, creator of the first resuscitation mannequin, "Resusci Annie"[14] and by Denson and Abrahamson, creators of "SimOne," which despite being a pioneer, could not be disseminated, among other factors, due to its high cost at the time of its creation.[15,16]

Two major areas positively influenced simulation in healthcare as we know it today: the military and the aviation industry. From the military, we borrowed the concept of debriefing used during World War II in the work of S.L.A. Marshall.[17] Marshall noted that when a person describes what happened to him or her during a distressing experience, it allows colleagues to correct misperceptions and provide social support, decreasing the development of post-traumatic reactions, restoring unit cohesion, and enabling a return to combat. From the aviation industry came the influence of realism: how similar the simulation is compared to real life. Such realism was achieved through the flight simulators that have emerged starting in 1929, the "Blue Box" or "Link Trainer," and the healthcare field incorporated the concept.[18]

The publication in 1999 of the book "To err is human: building a safer health system" by the U.S. Institute of Medicine is landmark of simulation in healthcare. This book presented human error as the main cause of adverse events that lead to unfavorable outcomes for patients. Many of the errors could be avoided, and therefore, it is important to design safety measurements into the patient care processes systematically. The book also presents a series of recommendations to achieve a threshold change in quality, and among others, recommends the adoption of simulation as a method for multidisciplinary training.[19]

In the last decade, there has been an exponential growth in the use of simulation in healthcare, in all levels of educational training, for students, residents, and continued education.[20] The use of this and other innovative teaching methods has become a necessity due to the poor performance of most graduates, mainly in the practice of clinical skills, application of knowledge, and problem-solving.[21] Also, the lack of critical events that are a source of learning and acquisition of different skills and the difficulty in teaching using real patients guarantee their ethical and legal rights.[22] These are other factors that have favored the growth of the use of simulation-based education in healthcare.

Simulation as a teaching tool

Simulation-based education is characterized by pedagogical strategies, technology, complexity, and breadth of tasks that prepare students for professional life.[23] There are numerous advantages of using simulation as a teaching tool, such as the possibility of repetition, experiencing authentic clinical situations, practice in a safe environment, learning from error, living standardized experiences, and feedback on the practice. Before explaining each of these concepts, we will provide an overview of learning from a cognitive perspective.

Simulation enhances skill acquisition, but studies have shown that these skills will decay over time when not used. For example, a surgical skill will decay over time after periods of non-use[24], and the lack of the required skill will be a threat to patient safety. Studies have found that students were unable to perform the required skill 1[25], 6[26,27], or 12[26] months after completion of training proficiently. McKenna and Glendon[28] (1985) also found that only one-quarter of 120 professional rescuers were still proficient 6 months after receiving training in cardiopulmonary resuscitation.

Learning from a cognitive perspective

To better understand the reason for the lack of proficiency after training, it is necessary to understand how the process of skill acquisition works. Cognitive psychology distinguishes between declarative and procedural knowledge. Declarative knowledge refers to "knowing what," that is, knowledge about facts and events. Procedural knowledge refers to "knowing how."[29] While declarative memory decays over time; procedural memory is not affected by time.[30]

All learning starts with declarative knowledge, for example, through instructions or observations. In this first moment, where most of the knowledge is declarative, performance is slow and subject to error since declarative knowledge is forgettable and difficult to retrieve. The knowledge in declarative memory degrades with lack of use, leading to an inability to perform the task. With practice, however, knowledge is represented using a mixture of declarative and procedural memory, so training is required to keep declarative knowledge active. Subsequently, declarative knowledge is transformed in procedural format; procedural memory is immune to deterioration.[30]

Thus, the fact that medical knowledge is often forgotten refers to integrating the two types of knowledge, declarative and procedural. That raises an important question that in addition to the use of simulation for learning, it is necessary to reflect on how the educational process itself can be adapted to change learning from short-term to long-term memory.[31] Consider two common scenarios in teaching: blood pressure measurement and cardiac arrest care, the first is a skill that students will use more frequently throughout the course and in professional practice, while the second will be used less often. Therefore, it is not recommended that the same simulation strategy is used during their teaching. Before presenting the recommendations for the two scenarios, some important concepts that promote long-term retention will be discussed, such as the spacing effect, interleaved practice, testing effect, and feedback.

Spacing effect

The spacing effect or spaced practice refers to the finding that educational encounters and/or training sessions spaced and repeated over time result in better learning retention than teaching in a single encounter.[31] The benefits of spacing practice sessions have long been confirmed in the literature, including studies on skill retention in health care.[24] For example, Spruit and colleagues[32] (2015) demonstrated that spaced practice in laparoscopic skills facilitates skill acquisition and short- and long-term retention and is, therefore, more effective for students.

Why spaced practice is more effective than intensive practice can be explained by the fact that to incorporate the new learning into long-term memory requires a consolidation process; that is, the representations of the new learning gain meaning by being strengthened and connected to prior knowledge. This process can take several hours or several days. Therefore, retention requires time for mental repetitions and the other consolidation processes. When intensive practice is done in a single encounter, learning relies on short-term memory.[33]

Testing effect

The testing effect refers to the retention advantage of tested material over the material presented for further study.[34,35] Several studies point out that self-testing improves learning and long-term retention, with retesting more efficient than studying again.[36,37] Retrieving information from one's own memory favors modifying one's own memory trait, consequently increasing the possibility of future success in retrieving learned information.[38] Several studies elucidate that the test improves learning and long-term retention in the form of quizzes, games, flashcards, among others, and that testing several times in spaced sessions is more efficient than studying again.[37-39] Studies performed by the same group and using the skill (CPR) found that students had better retention of knowledge when they were tested instead of practicing the same skill again.[35,39]

Interleaved practice

The concept of interleaved practice refers to learning two or more related skills, topics, concepts, or principles in an interleaved manner, as they are mixed rather than separated into blocks, practicing more randomly and less predictably.40 The benefit of interleaved practice in acquiring and retaining motor skills is also well documented in the literature.[41-44] However, health-related studies are still scarce.

One explanation of why interleaved practice is more effective than single-concept practice is that interleaving improves the brain's ability to distinguish or discriminate concepts. That is, each practice attempt is different from the last, so mechanical responses do not work. Instead, the brain must continually focus on finding different solutions. This process may improve its ability to learn essential features of skills and concepts, which allows it to better select and execute the correct response.[45] Another possible explanation is that interleaving allows for a more varied training context than practicing a single concept, and this variability introduces interference and is beneficial for long-term retention.[46]

Reflection

Another form of information retrieval practice is reflection. Reflection helps us analyze what was learned in an experience and is considered essential as quizzes and tests, and can accomplish simple questions such as: What happened? What did I do? How did it work? What would I do differently next time?[33] By answering these simple questions, which are usually present in the final stage of simulation scenarios, the debriefing, students learn from the experience and obtain better results.

Feedback

Feedback should always be present in learning sessions. According to Hattie[47] and Timperley, feedback is one of the most powerful influences on learning and can be described as information provided by an agent about aspects of their performance or understanding. Feedback is critical to support cognitive, technical, and professional development.[48] To be effective, feedback must be clear, objective, meaningful, compatible with the student's prior knowledge, and provide logical connections, promoting positive and desirable development.[47,48] It is possible to find several types, structures, and the optimal timing of providing feedback to the student described in the literature.[48-52]

As for type, feedback can be directive or facilitative; the former informs the student what requires correction, the latter involves providing comments and suggestions to facilitate recipients in their own revision. Whether directive or facilitative, the feedback can also vary in its structure: verification or elaboration. Verification feedback indicates whether the answer is right or wrong, and elaboration feedback facilitates the recipient in arriving at the correct answer. Besides being of various types, feedback can be structured differently: written, verbal or numerical. Its format is probably related to the context in which it is generated. For example, specific response facilitation of written feedback generated from a written exam can increase its effectiveness.

The timing of feedback may independently influence its effectiveness. The evidence suggests that effectiveness and timing are related to the focus and difficulty of the task.[24] Feedback after the simulation (terminal) may be better for supporting knowledge transfer, whereas feedback during the simulation (concurrent) may be more effective in the short term and for supporting the development of procedural skills.[24] In motor learning, which is often trained in simulation, the literature recommends using terminal feedback, which despite being more uncomfortable for the learner, proves to be more effective in acquiring a motor skill when compared to concurrent feedback. That is because, in motor learning, one theory holds that when feedback is concurrent, it becomes part of the task, and later, in a real-world context, its absence becomes a gap in the established automaticity, hindering long-term performance. For complex skills, terminal feedback may not be feasible. Thus, the gradual removal of feedback is suggested. It is also worth mentioning that terminal feedback has better results for knowledge retention.

Regardless of the model, we advocate that feedback should be applied objectively, allowing students to align what he knows and does not know, eliminating illusions.[33] In the simulation, feedback moments are extremely important, as they allow the student to reflect on his own performance. Reflecting on what went right, what went wrong, and how it can be done differently next time helps us isolate key ideas, organize them into mental models, and apply them again in the future, to improve and evolve on what we have already learned.[53]

Simulation-based education is already incorporated in healthcare education, with evidence proving it is valuable.[21,22] However, it is crucial to align the use of simulation with the strategies described above since it increases skill acquisition and retention. Finally, we would like to reinforce that despite all the benefits of learning using simulation, achieving expertise requires clinical experiences with practice in a real environment, always accompanied by a supervisor and receiving feedback.

Recommendations

Before the recommendations, we need to see the difference between acquisition and retention. Whereas skill acquisition means "gaining a new" skill that was not previously understood or exists, skill retention refers to the process of performance after a period of non-use. The difference between skill acquisition and retention will help us optimize the simulation training design using cognitive psychology concepts. Below are two practical examples of how to apply each of these concepts according to their purpose.

1. Blood pressure measurement: In this case, the focus should be on skill acquisition because students will frequently practice during their training. For situations where the focus is on skill acquisition, it is recommended to have a single session, ideally one or two days before the practice starts, with terminal feedback, after the performance (testing effect).

2. Cardiopulmonary arrest care: In this case, the focus is on skill retention because students have few opportunities to practice during training. For situations in which the focus is on skill retention, it is recommended to perform spaced and interleaved sessions using the testing effect. The amount of feedback should decrease over time until students can perform without assistance.

Regarding feedback, if the skill is complex, we recommend that the concurrent feedback is removed gradually. On the other hand, when the skill is simple, we recommend terminal feedback.

Conclusion

In this article, we discussed the key concepts that improve skill acquisition and retention. In addition, we reinforce that both acquisition and retention are active processes. That is, learning will occur only if the student takes an active role in the process. Therefore, using simulation combined with the key concepts may provide even better results for skill acquisition and retention.

Acknowledgments

FAPESP partially funded this research – São Paulo Research Foundation [Young Investigator Grant number 2018/15642-1] awarded to Dario Cecilio-Fernandes and [Postdoctoral Grant number 2020/07132-3] awarded to Danielle Rachel dos Santos Carvalho. The funder had no role in study design, data collection, analysis, decision to publish, or manuscript preparation.

References

1. Gaba DM. The future vision of simulation in health care. Qual Saf Health Care. 2004;13(Suppl 1):i2–10. http://dx.doi.org/10.1136/qshc.2004.009878

2. Vázquez-Mata G, Guillamet-LLoveras A. El entrenamiento basado en la simulación como innovación imprescindible en la formación médica. Educ Med [Internet]. 2009;12(3):149-55. Available from: https://scielo.isciii.es/pdf/edu/v12n3/revision.pdf

3. Brandão CFS, Collares CF, Cecilio-Fernandes D. Simuladores, pacientes padronizados e híbridos. In: Scalabrini Neto A, Fonseca AS, Brandão CFS. Simulação clínica e Habilidades na saúde. São Paulo: Editora Atheneu; 2020. pp.11-21.

4. Cook DA. How much evidence does it take? A cumulative meta-analysis of outcomes of simulation-based education. Med Educ. 2014;48(8):750–60. https://doi.org/10.1111/medu.12473

5. Wang EE. Simulation and adult learning. Dis Mon. 2011;57(11):664–78. https://doi.org/10.1016/j.disamonth.2011.08.017

6. Argullós JLP, Sancho CG. El uso de las simulaciones em educacíon médica. TESI [Internet]. 2010;11(2):147-69. Available from: https://revistas.usal.es/index.php/eks/article/view/7075

7. Raemer DB. Team-oriented medical simulation. In: Dunn WF, editor. Simulators in critical care education and beyond. Des Plaines, IL: Society of Critical Care Medicine; 2004. pp 42–6.

8. Kaufman DM. Applying educational theory in practice. BMJ. 2003;326(7382):213–6. https://doi.org/10.1136/bmj.326.7382.213

9. Issenberg SB, McGaghie WC, Petrusa ER, Lee Gordon D, Scalese RJ. Features and uses of high-fidelity medical simulations that lead to effective learning: a BEME systematic review. Med Teach. 2005;27(1):10-28. https://doi.org/10.1080/01421590500046924

10. Zigmont JJ, Kappus LJ, Sudikoff SN. The 3D model of debriefing: defusing, discovering, and deepening. Semin Perinatol. 2011;35(2):52-8. https://doi.org/10.1053/j.semperi.2011.01.003

11. Neri-Vela R. El origen del uso de simuladores en Medicina. Rev Fac Med UNAM [Internet]. 2017;60(S1):21-7. Available from: https://www.medigraphic.com/cgi-bin/new/resumen.cgi?IDARTICULO=77104

12. Perkins GD. Simulation in resuscitation training. Resuscitation. 2007;73(2):202-11. https://doi.org/10.1016/j.resuscitation.2007.01.005

13. Sahu S, Lata I. Simulation in resuscitation teaching and training, an evidence-based practice review. J Emerg Trauma Shock. 2010;3(4):378-84. https://doi.org/10.4103/0974-2700.70758

14. Tjomsland N, Baskett P, Laerdal AS. Resuscitation. 2002;53(2):115-9. https://doi.org/10.1016/s0300-9572(02)00033-3

15. Denson JS, Abrahamson S. A computer-controlled patient simulator. JAMA. 1969;208(3):504-8. Cited: PMID: 5818529

16. Rosen KR. The history of medical simulation. J Crit Care. 2008;23(2):157-66. https://doi.org/10.1016/j.jcrc.2007.12.004

17. Marshall SLA. Bringing up the Rear: A Memoir. San Rafael, US: Presidio Press; 1979.

18. Bradley P. The history of simulation in medical education and possible future directions. Med Educ. 2006;40(3):254–62. https://doi.org/10.1111/j.1365-2929.2006.02394.x

19. Kohn LT, Corrigan J, Donaldson MS. To err is human: building a safer health system. Washington, D.C.: National Academy Press; 2000.

20. Kelly M, Jeffries P. Clinical simulation in health care—– Contemporary learning for safety and practice. Collegian. 2012;19(3):115-6. https://doi.org/10.1016/j.colegn.2012.07.002

21. Elshama SS. How to Develop Medical Education (Implementation View). Atlanta: Scholars' Press; 2016.

22. McGaghie WC, Issenberg SB, Petrusa ER, Scalese RJ. A critical review of simulation-based medical education research: 2003-2009. Med Educ. 2010;44(1):50-63. https://doi.org/10.1111/j.1365-2923.2009.03547.x

23. Elshama SS. How to apply Simulation-Based Learning in Medical Education? Iberoam J Med. 2020;2(2):79-86. http://doi.org/10.5281/zenodo.3685233

24. Cecilio-Fernandes D, Cnossen F, Jaarsma DA, Tio RA. Avoiding Surgical Skill Decay: A Systematic Review on the Spacing of Training Sessions. J Surg Educ. 2017;75(2):471-80. https://doi.org/10.1016/j.jsurg.2017.08.002

25. Moazed F, Cohen ER, Furiasse N, Singer B, Corbridge TC, McGaghie WC, et al. Retention of critical care skills after simulation-based mastery learning. J Grad Med Educ. 2013;5(3):458-63. https://doi.org/10.4300/jgme-d-13-00033.1

26. Barsuk JH, Cohen ER, McGaghie WC, Wayne DB. Long-term retention of central venous catheter inser- tion skills after simulation-based mastery learning. Acad Med. 2010;85(10 suppl):S9-12. https://doi.org/10.1097/acm.0b013e3181ed436c

27. Wik L, Myklebust H, Auestad BH, Steen PA. Retention of basic life support skills 6 months after training with an automated voice advisory manikin system without instructor involvement. Resuscitation. 2002;52(3):273-9. https://doi.org/10.1016/s0300-9572(01)00476-2

28. McKenna S, Glendon A. Occupational first aid training: decay in cardiopulmonary resuscitation (CPR) skills. J. Occup. Psychol. 1985;58(2):109-17. https://doi.org/10.1111/j.2044-8325.1985.tb00186.x

29. Anderson JR. Acquisition of cognitive skill. Psychol Rev. 1982;89(4):369-406. https://psycnet.apa.org/doi/10.1037/0033-295X.89.4.369

30. Kim JW, Ritter FE, Koubek RJ. An integrated theory for improved skill acquisition and retention in the three stages of learning. Theor Issues Ergon Sci. 2013;14(1):22-37. https://doi.org/10.1080/1464536X.2011.573008

31. Kerfoot BP, DeWolf WC, Masser BA, Church PA, Federman DD. Spaced education improves the retention of clinical knowledge by medical students: a randomised controlled trial. Med Educ. 2007;41(1):23-31. https://doi.org/10.1111/j.1365-2929.2006.02644.x

32. Spruit EN, Guido PH, Jaap B, Hamming F. Increasing efficiency of surgical training: effects of spacing practice on skill acquisition and retention in laparoscopy training. Surg Endosc. 2015; 29(8):2235–43. https://doi.org/10.1007/s00464-014-3931-x

33. Brown P, Roediger HL, McDaniel MA. Fixe o conhecimento: a ciência da aprendizagem bem-sucedida. Porto Alegre: Penso; 2018.

34. Allen GA, Mahler WA, Estes WK. Effects of recall tests on long-term retention of paired associates. J Verbal Learning Verbal Behav. 1969;8(4):463-70. https://psycnet.apa.org/doi/10.1016/S0022-5371(69)80090-3

35. Kromann CB, Jensen ML, Ringsted C. The effect of testing on skills learning. Med Educ. 2009;43(1):21-7. https://doi.org/10.1111/j.1365-2923.2008.03245.x

36. Agarwal P, Karpicke J, Kang S, Roediger H, McDermott K. Examining the Testing Effect with Open- and Closed-Book Tests. Appl Cogn Psychol. 2008;22(7):861-76. https://doi.org/10.1002/acp.1391

37. Roediger HL, Karpicke JD. The Power of Testing Memory: Basic Research and Implications for Educational Practice. Perspect Psychol Sci. 2006;1(3):181-210. https://doi.org/10.1111%2Fj.1745-6916.2006.00012.x

38. Eisenkraemer RE, Lilian AJ, Stein M. A Systematic Review of the Testing Effect in Learning. Paidéia. 2013;23(56):397-406. https://doi.org/10.1590/1982-43272356201314

39. Kromann CB, Bohnstedt C, Jensen ML, Ringsted C. The Testing Effect on Skills Learning Might Last 6 Months. Adv Health Sci Educ. 2015;41(5):1540-7. https://doi.org/10.1007/s10459-009-9207-x

40. Benassi VA, Overson CE, Hakala CM. Applying science of learning in education: Infusing psychological science into the curriculum [Internet]. University of New Hampshire: Society for the Teaching of Psychology; 2014. Available from: https://teachpsych.org/ebooks/asle2014/index.php

41. Taylor K, Rohrer D. The effects of interleaved practice. Appl Cogn Psychol. 2010;24(6):837-48. https://doi.org/10.1002/acp.1598

42. Mayfield KH, Chase PN. The effects of cumulative practice on mathematics problem solving. J Appl Behav Anal. 2002;35(2):105-23. https://dx.doi.org/10.1901%2Fjaba.2002.35-105

43. Carpenter SK, Mueller FE. The effects of interleaving versus blocking on foreign language pronunciation learning. Memo Cognit. 2013;41:671-82. https://doi.org/10.3758/s13421-012-0291-4

44. Hall KG, Domingues DA, Cavazos R. Contextual interference effects with skilled baseball players. Percept Mot Skills. 1994;78(3 Pt 1):835-41. https://doi.org/10.2466/pms.1994.78.3.835

45. Pan SC. The interleaving effect: mixing it up boosts learning. Sci Am [Internet]. 2015;313(2). Available from: http://www.tinyurl.com/y49q9bnn

46. Horvath JC, Lodge JM, Hattie J, editores. From the laboratory to the classroom: Translating science of learning for teachers. Nova Iorque; Londres: Routledge; 2017.

47. Hattie J, Timperley H. The Power of Feedback. Rev Educ Res. 2007;77(1):81-112. https://doi.org/10.3102%2F003465430298487

48. Archer JC. State of the science in health professional education: effective feedback. Med Educ. 2010;44(1):101-8. https://doi.org/10.1111/j.1365-2923.2009.03546.x

49. Waldrop PB, Justen JE, Adams TM. A Comparison of Three Types of Feedback in a Computer-Assisted Instruction Task Author(s). Education Technology [Internet]. 1986;26(11):43-5. Available from: https://www.jstor.org/stable/44424764

50. Jaehnig W, Miller ML. Feedback Types in Programmed Instruction: A Systematic Review. Psychol Rec. 2007;57(2):219-32. http://dx.doi.org/10.1007/BF03395573

51. Finn B, Metcalfe J. Scaffolding feedback to maximize long-term error correction. Mem. Cogn. 2010;38(7):951-61. https://doi.org/10.3758/MC.38.7.951

52. Kulik JA, Kulik CC. Timing of feedback and verbal learning. Rev Educ Res. 1988;58(1):79-97. https://doi.org/10.3102%2F00346543058001079

53. Gernsbacher MA, Varner KR, Faust ME. Investigating differences in general comprehension skill. J Exp Psychol Learn Mem Cogn. 1990;16(3):430-45. https://doi.org/10.1037//0278-7393.16.3.430