Simulation-Based Learning

General

Simulation-based learning is a constructivist learning model that provides learners with an experience of working on an usually simplified **simulated world or system**. This approach, widely adopted in military and aviation "*to maximize training safety and minimize risk*"[1], is today used extensively, especially in the medical education.

What is simulation-based learning?

A simulation can be defined as a model of reality reflecting some or all of its properties. Robert Gagne identified the following properties of a simulation as crucial[2]:

- *A simulation represents a real situation in which operations are carried out.*
- *A simulation provides the user with certain controls over the problem or situation.*
- *A simulation omits certain distracting variables irrelevant or unimportant for the particular instructional goals.* Simulation = (Reality) - (Task irrelevant elements)

Simulation-based learning today mostly relies on usage of computers and advanced technologies to provide a near authentic experience for the user and enhance learning. As a learning tool, simulations mostly rely on some other learning theory and implement its principles.

Yet what is characteristic for simulation-based learning is the discovery that system representations are often to complex and difficult for a novice to facilitate his learning. Even though principles of human cognitive structure and methods of reducing cognitive load were taken into account while designing a simulation, it has been shown that learners are still frequently unable to successfully relate multiple representation elements to each other. This issue can be described in the context of prior knowledge as well.[3] Two successful ways of dealing with this issue have been proposed so far:

- **active integration** of representations[4] into complex system by the learner (for example link names of the elements to their symbol representations)[5], and
- **model progression**, or starting with a simple simulation models and then slowly increasing their complexity[6][7].

Simulation-based learning can also be guided or unguided, yet research has shown that instructional help in form of hypotheses to prove, offered interpretations, assignments to complete or structuring can be useful[8][9][10].

What is the practical meaning of simulation-based learning?

Simulation-based learning **examples** can today often be found in medical [11], physics[12], biology[13] education and other fields as well and the results were positive[14]. An example of this is "Harvey", a cardiology patient simulator. A recent study[15] has further showed the superiority of simulation-based learning to problem-based learning (also applied in medicine schools) in case of learning of critical

assessment and management skills.

As simulation-based learning is frequently used in medical education[16], a recent study has examined result of 670 related articles and identified 10 key aspects of simulation-based learning in medical education which enhance learning[17]:

- providing **feedback** to the students,
- repetitive **practice** leading to skill improvement,
- curriculum **integration** of simulation-based learning,
- practicing with range of **difficulty levels** (usually increasing),
- multiple **learning strategies** and not just teacher-centered approach,
- using simulators that reflect a variety of patient problems,
- controlled environment where there is no negative consequences of an error,
- **active** individualized learning,
- clearly defined and measured **outcomes**,
- simulator is a highly similar to actual clinical practice.

Criticisms

Many previous studies in this area found that, at least for **novice learners**, simulation-based learning is hard and that they have problems in establishing goals and their results in learning through simulation[18][19] or that they have **problems with verbalizing** results and gained knowledge[20]. It seemed that richness of the information a student can extract from a simulation makes his **learning more difficult** unless it is first simplified and well structured.

Keywords and most important names

- **Simulation-based leaning**
- Ton de Jong

Bibliography

Swaak, J., van Joolingena, Wouter R. and de Jong, T. Supporting simulation-based learning; the effects of model progression and assignments on definitional and intuitive knowledge. Learning and Instruction, 8(3), p235-252. June 1998.

Bodemer, D. Enhancing Simulation-Based Learning through Active External Integration of Representations. In Proceedings of the Twenty-Sixth Annual Conference of the Cognitive Science Society, 138–143, 2005.

Read more

Jong de, T., and Sarti, L. Design and production of multimedia and simulation-based learning material.

Kluwer Academic Publishers Group. 1994.

Bodemer, D. Enhancing Simulation-Based Learning through Active External Integration of Representations. In Proceedings of the Twenty-Sixth Annual Conference of the Cognitive Science Society, 138–143, 2005.

Weller, J., Robinson, B., Larsen, P. and Caldwell, C. Simulation-based training to improve acute care skills in medical undergraduates. The New Zealand Medical Journal 117, no. 1204: U1119. October 2004.

1)

Ziv, A., P. R Wolpe, S. D Small, and S. Glick. Simulation-based medical education: an ethical imperative. Simulation in Healthcare 1, no. 4: 252. 2006.

2)

Cited by Lunetta, Vincent N, and Avi Hofstein. Simulations in science education. Science Education 65, no. 3: 243-252. July 1, 1981.

3) , 5)

Bodemer, D. Enhancing Simulation-Based Learning through Active External Integration of Representations. In Proceedings of the Twenty-Sixth Annual Conference of the Cognitive Science Society, 138–143, 2005.

4)

Representations are another issue of simulation-based learning since their efficiency is domain dependent. For example, efficiency of various types of representations in simulation-based learning of statistics is described in Kollöffel, Bas Jan. Getting the picture : the role of external representations in simulation-based inquiry learning. University of Twente, 2008.

6)

White, B. Y. and Frederiksen, J. R. Causal model progressions as a foundation for intelligent learning environments. Artificial Intelligence, 42, p99–157. 1990.

7)

Brydges, Ryan, Heather Carnahan, Don Rose, and Adam Dubrowski. Comparing self-guided learning and educator-guided learning formats for simulation-based clinical training. Journal of Advanced Nursing 66, no. 8: 1832-1844. August 1, 2010.

8)

de Jong, T., & van Joolingen, W. R. Scientific discovery learning with computer simulations of conceptual domains. Review of Educational Research. 1997.

9)

Swaak, Janine, and And Others. Support for Simulation-Based Learning; The Effects of Model Progression and Assignments on Learning about Oscillatory Motion., March 1996.

10)

de Jong, T., W. R. van Joolingen, J. Swaak, K. Veermans, R. Limbach, S. King, and D. Gureghian. Self-directed learning in simulation-based discovery environments. Journal of Computer Assisted Learning 14, no. 3: 235-246. September 1998.

11)

See: Issenberg, S. B., Pringle, S., Harden, R. M., Khogali, S. and Gordon, M. S. Adoption and integration of simulation-based learning technologies into the curriculum of a UK Undergraduate Education Programme. Medical Education 37, no. s1: p42-49. November 2003.

12)

See: Lee, Yu-Fen, and Yuying Guo. Explore Effective Use of Computer Simulations for Physics Education. Journal of Computers in Mathematics and Science Teaching 27, no. 4: 443-466. October 2008.

13)

Akpan, Joseph P. Issues Associated with Inserting Computer Simulations into Biology Instruction: A Review of the Literature 5, no. 3, 2001.

14)

McGaghie, W. C., Issenberg, S. B., Petrusa, E. R. and Scalese, R. J. Effect of practice on standardised learning outcomes in simulation-based medical education. Medical Education 40, no. 8: p792-797. August 2006.
15)

Steadman, Randolph, H., Coates, Wendy C., Huang, Y. M., Matevosian, R., Larmon, Baxter R., McCullough, L. and Ariel, D. Simulation-based training is superior to problem-based learning for the acquisition of critical assessment and management skills. Critical Care Medicine 34, no. 1: p151-157. January 2006.
16)

For motivation see Lateef, Fatimah. Simulation-based learning: Just like the real thing. Journal of Emergencies, Trauma, and Shock 3, no. 4: 348. 2010.
17)

Barry Issenberg, S., William C. Mcgaghie, Emil R. Petrusa, David Lee Gordon, and Ross J. Scalese. Features and uses of high-fidelity medical simulations that lead to effective learning: a BEME systematic review. Medical Teacher 27, no. 1: 10-28. January 2005.
18)

Glaser, R., Schauble, L., Raghavan, K., & Zeitz, C. Scientific reasoning across different domains. In E. de Corte, M. Linn, H. Mandl and L. Verschaffel (Eds.), Computer-based learning environments and problem solving (NATO ASI series F: Computer and Systems Series) (p345–373). Berlin: Springer. 1992.
19)

Shute, V. J., & Glaser, R. A large-scale evaluation of an intelligent discovery world: Smithtown. Interactive Learning Environments, 1, p51–77. 1990.
20)

Njoo, M., and De Jong, T. Exploratory learning with a computer simulation for control theory: Learning processes and instructional support. Journal of Research in Science Teaching, 30, p821–844. 1993.