HOW NEUROSCIENCE AND BRAIN-BASED LEARNING THEORY CAN ENHANCE SKILL DEVELOPMENT OF STUDENTS IN HIGHER EDUCATION

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ABSTRACT

Simulations are highly effective learning tools based on the foundations of neuroscience, brain-based learning theory, and neuropedagogy. Simulations and gamifications result in greater student involvement and knowledge retention than conventional instruction. In 2018, a pilot program was launched in the Emergency and Disaster Management program at American Military University in which traditional readings, lectures, and text were replaced with simulations. Various student performance measures were analyzed and showed improvement over the traditional method of instruction, and it was concluded that these improvements were due to the nature of the simulations. The greater use of simulations in education will enhance the quality of instruction and develop students' cognitive skills.

Keywords: *gamification, learning theory, neuropedagogy, neuroplasticity, simulations*

INTRODUCTION

Research has confirmed our brain's ability to change and develop throughout our lifetime and learn new information regardless of age. This ability is known as neuroplasticity, the brain's ability to grow and develop new neural pathways irrespective of age. This paper provides a brief overview of the neuroscience of learning and how the concept was applied in a simulation curriculum in the Emergency and Disaster Management (EDMG) program at American Military University (AMU).

NEUROPLASTICITY AND NEUROPEDAGOGY

The concept of neuroplasticity can be traced back to the late 18th century when Michele Vincenzo Giacinto Malacarne, who at the time was the chief surgeon at a hospital in Turin, Italy, conducted a series of experiments in which he trained birds to complete various complex tricks (Raz & Lindenberger, 2013). Once trained, he killed them and examined their brains, comparing them to the brains of untrained birds. He found that the trained birds "had more extensive folding patterns in specific regions of their brains than his untrained birds." (Medina, 2014, p. 87) The finding suggests that learning causes physical changes to the brain; modern-day imaging techniques have proven this true.

A concise and modern definition of neuroplasticity is provided by Marks (2021) in the *Medterms Medical Dictionary* where "the brain's ability to reorganize itself by forming new neural connections throughout life" (para. 1). This is similar to the definition put forth by Voss et al. (2017) who describe it as "a general umbrella term that refers to the brain's ability to modify, change, and adapt both structure and function throughout life and in response to experience" (p. 1). Simply put, the brain can learn throughout its lifetime, and new neural pathways are created when new knowledge is acquired. Educators can develop better students with greater retention of knowledge if they design learning programs that support the brain's ability to change and grow.

PROBLEM STATEMENT

A desire to better serve students through implementing learning based on the neuroplasticity concept resulted in a pilot program launched in the EDMG program at AMU. Starting in March 2018, subject matter experts in EDMG worked alongside instructional designers with a background in simulations and gamification. The project was overseen by the dean and associate dean, who provided the framework for brain-based learning and guidance on neuroplasticity. Since vision trumps all senses, using an immersive learning environment was critical to the pilot (Medina, 2014).

METHODOLOGY

Extensive research into neuroplasticity, neuropedagogy, the nature of memory, and measures of student success was conducted before developing the simulations. Considering all of this, the simulations were designed to produce learning content that engaged the sensory cortex and allowed for more efficient retention of learning material. Finally, each class simulation is directly tied into other class simulations throughout the program. This was done to support the brain's ability to process information presented in "chunks" (Drumhiller et al., 2019; Medina, 2018; Vembunarayanan, 2014).

In what can be considered a pathway of simulations, the students began their journey in the *Introduction to Emergency Management* course (EDMG 101). An immersive 3D environment was created that required students to assume various roles of emergency management officials. Throughout the eight-week course, leaders in emergency operations centers routinely face numerous challenges. Faculty provided injects into the simulation, which included role-playing various agency officials, responding to student communication, and guiding and coaching students throughout the course. Upon completing the course, students completed a hazard vulnerability assessment that they took into the follow-on emergency planning course. We attempted to carry the learning from one class into the next and ensure it was retained in the student's memory. Throughout the six-course program, students' roles within the simulation changed, and the complexity of the events facing them grew in difficulty (Drumhiller et al., 2019).

FINDINGS

After running seven simulation sessions, the design group collected and analyzed data from student performance measures and feedback from students and faculty and were pleased with the initial results. Table 1 shows quantitative improvements in the DFWI rate (D [pass], F [fail], W [withdraw], incomplete [I]), as well as improvements in the final grade. These improvements occurred even though the rigor of the course increased. At the same time, the delivery of the material changed from the traditional reading of material followed by an exam to a simulation.

We also discovered that many students voluntarily repeated parts of the simulation to make different decisions and learn how those changes affected the scenario's outcome. We also found increased knowledge retained from the first class and into each subsequent class. This was measured quantifiably through an observed increase in skills used to map a disaster and anecdotally through comments and actions that students displayed in subsequent classes. While it did not remove the faculty member from the classroom, the nature of the simulation provided a reduction in the amount of work required of the instructor, which led to a noticeable increase in faculty morale and an improvement in their work-life balance.

Table 1. Student Improvements in EDMG Courses

EDMG 101 (7 sessions)
1. A 2% DFWI decrease.
2. An increase in students earning an A or B from 84% to 88% and an increase of students earning an A or A- increased by 18%
EDMG 230 (5 sessions)
1. A 5% increase in DFWI which we attribute to the Week 7 forum.
2. A decrease in students earning an A or B from 89% to 84% and an increase in students earning a D from 2% to 5%
EDMG 320 (7 sessions)
1. A 2% decrease in Withdrawals.
2. An increase in students earning an A or B from 78% to 87%.
EDMG 321 (3 sessions)
1. A 3% decrease in DFWI.
2. An increase in students earning an A or B from 74% to 84% and the withdrawals dropped from 10% to 3% *Note:* DFWI = [D] pass, [F] fail, [W] withdraw [I] incomplete

CONCLUSION

Simulations were successfully used in undergraduate coursework in EDMG studies at AMU. They resulted in greater retention of knowledge for students and increased motivation and excitement on the part of the faculty. Based on the theory of brain-based learning and neuroscience, the simulations were designed to create the specific conditions necessary to stimulate various areas of the brain involved in learning and memory.

The cost of a college degree continues to rise, while at the same time, students and parents are demanding a greater return on their investment. At the time of this writing, student debt in the United States is front-page news, and the Supreme Court of the United States is scheduled to hear arguments on two student loan forgiveness cases that could authorize the forgiveness of student loan debt of up to $20,000 per applicant (Burga, 2023). If the value of a college degree or specific programs within the degree retain relevance, then methods of instruction that improve student outcomes based on scientific theory should become commonplace.

Further study is necessary for this area to develop a clear understanding of faculty faith in using simulations. If an initiative is to be undertaken at a university and does not have faculty support, it is doomed to fail. Specific to intelligence education, there would be value in a better understanding and developing cognitive skills and communication. After the initial cost of products, simulations are relatively low-cost/high payoff tools that dramatically benefit students and faculty and can set an institution apart from its peers when grounded in the neuroscience of learning.

RECOMMENDATIONS

Before investing the resources required for a simulation program, evaluating the current state and mapping out the future of the existing program would be prudent. In *The Academic Practitioner Divide in Intelligence Studies*, Ard (2022) presents several course suggestions for a successful intelligence education program and developing cognitive skills. Nimon (2013) found that cognitive skill development and the tenets of neuropsychology were essential to intelligence studies in higher education. Bruer (1997), a researcher and specialist in cognitive science and the philosophy of science, believes that cognitive psychology is the only proven method of "indirectly linking brain function with educational practice" (p. 4). Ard (2022) further suggests coursework in fundamentals of corporate security focusing on physical and travel security as well as on risk management, emergency management, and open-source analysis. All of these suggested courses make excellent candidates for simulations.

A recent literature review shows the importance of the development of cognitive skills for intelligence education programs. This assessment is supported by an extensive review conducted by Vlachopoulos and Makri (2017), who found numerous studies showing improved cognitive skills from simulation training. They provided an analysis of study results measuring the improvement or lack of progress of cognitive skills such as "deep learning…critical thinking and scientific reasoning…action-directed learning…transformative learning…knowledge acquisition and content understanding…spatial abilities…and problem-solving" (p. 15). They found varied results that shed more light on the controversial nature of gamification and simulations among some educators.

A more scientific study of simulation use was conducted by Chernikova et al. (2020), who examined 145 empirical studies and investigations involving the use of simulations in higher education. They discovered that simulation training had a significant positive effect on the development of advanced complex skills and a significant positive impact due to the instantaneous feedback students received when they completed a task in a simulation (Chernikova et al., 2020). Rather than wait days or longer for an instructor to evaluate a submission from a student, the simulation provides immediate feedback and guidance on completing the classroom journey. This type of feedback is built into the simulation. It gives the added benefit of reducing one part of the faculty workload while at the same time allowing the instructor to engage at a higher level with the students.The European Commission funded exciting work with simulations in law enforcement intelligence. It resulted in the creation of the Law Enforcement Intelligence Learning Applications project. Participants from Italy, Greece, Romania, and France collaborated on developing a simulation tool. The tool focused on two scenarios designed to improve an intelligence analyst's skills in critical thinking, awareness of cognitive biases, data analysis, decision-making under pressure, collaboration, creative intelligence, and communication skills (Zanasi et al., 2017).

Using simulations would also greatly enhance the learning of either too expensive or restrictive topics, such as certain types of collection or space-based intelligence, surveillance, and reconnaissance. This type of learning lends itself to use in intelligence analysis in industry as well as the education and training of future analysts (Zanasi et al., 2017). Simulations provide a secure and cost-efficient environment, resulting in more efficient learning and knowledge retention.

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