Chapter 27
Evolutionary and Ideation Concepts for Cybersecurity Education

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ABSTRACT

Evolution is a well-established biological theory, but some basic concepts can be abstracted and applied to non-biological domains such as the education domain for the purposes of knowledge sharing. There is a gap in the literature regarding how evolutionary processes can be applied to cyber security education. This article presents the general evolutionary algorithm and pairs it with an ideation technique (SCAMPER) to illustrate how certain evolutionary processes can be applied to cyber security education and learning. This paper does not attempt to close the gap, but rather offer a theoretical approach to address the gap.

INTRODUCTION

This research-in-process paper explores some evolutionary concepts and an innovative ideation technique or framework to find new approaches or applications to teaching cyber security. The paper extends a prior study on evolutionary systems and their application to cybersecurity learning (Gould, Block & Cleveland, 2018; Gould & Cleveland, 2018). Some definitions, examples, and frameworks are provided as a starting point, followed by some applications to cyber security. The paper concludes with a recommendation

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for quantitative research measuring the effectiveness of evolutionary concepts in the preparation and execution of cyber defense educational curricula.

Evolutionary Concepts

Forrester (1971) argued that a system is a set of components that function together to achieve some purpose. A system can be viewed as a network with interactive nodes also known as agents, parts, components, elements, or objects. These agents may interact with each other as well as with their environment. Relationships between agents may be strong, weak, or null; with other descriptions possible as well. The type of network or networks illustrate systems structure as matter, information, or energy flow into, through, and out of the system; systems exhibit behavior, and some systems exhibit some form of change or dynamics over time such as transitional, transformational, adaptation or learning, or evolutionary.

Mobus and Kalton (2015) offered a more formal definition of a system as a 6-tuple, described by a set of subsystems, a network or networks, the set of nodes inside and outside the system, the boundary conditions, the interactions among the nodes, and the history of the system. While a variety of definitions of systems exist and there is no specific consensus on the definition of a system, an organization fits the Forester's (1971), Mobus and Kalton's (2015) definitions as a system.

Systems may evolve whether by biological or non-biological means. Solar systems, organizations, technology, culture, religion, and systems of knowledge are examples of non-biological evolutionary systems. Hull (1988) and Aldrich et al. (2008), argued for a concept called generalized Darwinism. That is, the general principles of Darwinism apply not only to biological evolution but also to evolution of societies and culture.

Fichter, Pyle, and Whitmeyer (2010) argued that if the definition of evolutionary change includes change in "complexity, diversity, order, and/or interconnectedness then there are at least three distinct mechanisms, or theories of evolution: elaboration, self-organization, and fractionation" (p. 59). The authors concisely identified the general evolutionary algorithm as the cycle of elaborate diversity, select from the diversity, amplify the selection, and repeat. Beinhocker (2010) further abstracted these key processes as variation, selection, amplification, and repeat.

Figure 1 illustrates a substrate-neutral model of evolution linking three principles: variation (differentiation), selection, and replication (amplification). These principles, abstracted from biological evolution, can be applied to other systems that evolve as well, although by other mechanisms than biology. While some minor differences in terminology exist regarding the abstract processes of evolution, they are useful in thinking about organizational change. Berlinski (2000) noted, "an algorithm is a finite procedure, written in a fixed symbolic vocabulary, governed by precise instructions, moving in discrete steps 1,2,3, …., whose execution requires no insight, cleverness, intuition, or perspicuity, and that sooner or later comes to an end" (p. xvii). Thus, the general evolutionary algorithm provides insight into systems change as all systems vary, they change due to endogenous and exogenous pressures, and not all changes are successful.

Evolutionary theory proposes that nature creates lots of experiments, yet few are successful (2010). This same principle can be applied to systems of knowledge. That is, multiple variations may be generated, with selection reducing the number that are successful.

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