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Cybersecurity Education Employing Experiential Learning

Travis Lowe
travis.lowe@fountainheadcollege.edu

Casey Rackley

Abstract

ABSTRACT

The purpose of this paper is to discuss a curriculum design that employs Kolb's Experiential Learning Theory stages and Kolb's Learning Styles in four consecutive class sessions. The challenge each class is to present students with perplexing and often frustrating network problems that someday might be encountered on the job. By using Kolb's theory, students address those problems from the perspective of each learning style, while passing through each phase of the learning cycle. As a result, students gain stronger cognitive thinking skills and hands-on troubleshooting skills in preparation for work as network administrators or cybersecurity analysts.

Location
KC 400

Disciplines
Adult and Continuing Education | Curriculum and Instruction | Information Security | Management Information Systems | Technology and Innovation | Vocational Education

INTRODUCTION

This work-in-progress research explores how to escalate student learning by both applying Kolb's Experiential Learning Theory and placing students in a disorienting dilemma, or a scenario-based activity that is new to the student. Borrowing from Jack Mezirow's Transformational Learning Theory concept, a disorienting dilemma is a challenge "requiring certain balances and concessions that seem difficult and even counterintuitive at times" (Sill, Harward, & Cooper, 2009). An example of a disorienting dilemma employed by Southern Illinois University Edwardsville is a capstone project for an art and design program called Mexica. During alternating summers, fifteen studio art majors are invited to study abroad for several weeks to learn ceramics and weaving skills from native artists who speak Spanish and Mixtec. The dilemma lies in the disconnect caused by language differences. As professor Laura Strand discovered, "the first week the students get angry, the second week they start to relax, and by the third week Mexica becomes a transformative experience. Many Mexica participants have reported that Mexica changed their lives and their art forever" (Sill, Harward, & Cooper, 2009). Examined herein is Thunderhead Thursday, a weekly exercise in disorienting dilemmas designed to begin at the experience learning stage and spiral through all learning stages, while also having students perform activities targeting each of Kolb's Learning Styles. The results from this recurring event are expected to enhance student knowledge, skills, and abilities through transformation.

CURRICULUM DESIGN

After graduation, a student begins her first day on the new job. She learns that the network administrative team has quit because the network is under cyberattack from a suspected insider. This event most likely would cause even seasoned network administrators to question their skills and abilities.

That is one of the hypothetical scenarios featured in an event branded Thunderhead Thursday, which occurs for approximately four consecutive one-hour sessions. It continues throughout the year, with new exercises each time. The imagery of a thunderhead cloud is used to convey the vertical, thick, dark, towering storm cloud that is formed by powerful gusts of air. This is intended as an analogy for the disorienting dilemma. Logos and marketing are underway using the event's brand and seeking to attract more outside guests. Every semester, new students enter classes and follow this cycle for two semesters. Typically, these are the last two terms before graduation. The classroom is a sort of open house, where outside guests are invited to join, doughnuts are served, and a trophy is at stake. If a student is able to find all the network abnormalities during that night, the trophy is his reward.

Kolb's Learning Cycle

As explained by McLeod (2017), Kolb's theory perfectly overlays four distinct learning styles atop a learning cycle that has four stages. At the concrete experience stage, a new experience occurs or existing experience is interpreted anew. At the reflective observation stage, a learner reviews or ponders an experience. Inconsistencies are important during this stage. When reflection creates a new idea (analysis) or modifies an old idea (conclusion), abstract conceptualization occurs. At the testing stage, learning is subjected to active experimentation.

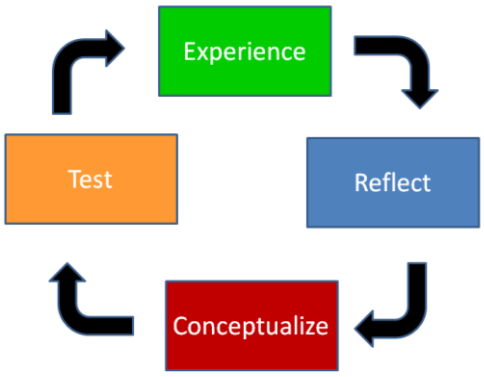

Figure 1. Kolb's four-stage learning cycle. Adapted from "Kolb's Learning Styles and Experiential Learning Cycle," by S. McLeod, 2017, Simply Psychology. *Retrieved July 16, 2018, from https://www.simplypsychology.org/learning-kolb.html.*

The cycle can be entered at any point, but no single stage promotes learning. Rather, all stages must be completed, so as to build efficacy with the student's learning (McLeod, 2017).

Kolb's Learning Styles

As shown in Figure 2, Kolb presents four learning styles on an axis in which two styles oppose one another. The theory states that a learner chooses one side of each axis, which results in his or her learning style. The east-west axis pertains to one's approach to a task, while the north-south axis pertains to how one feels about the task (McLeod, 2017).

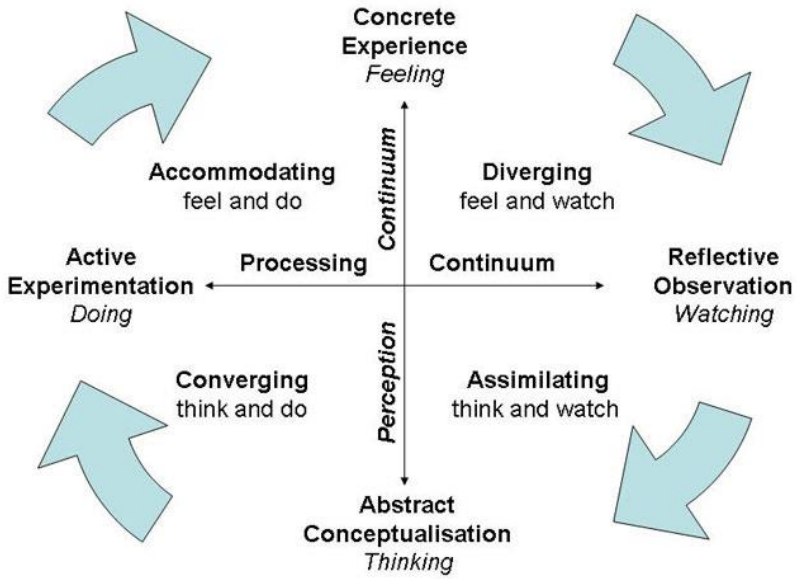

Figure 2. Learning cycle overlapped with approach to learning. From "Kolb's Learning Styles and Experiential Learning Cycle," by S. McLeod, 2017, Simply Psychology. *Retrieved July 21, 2018, from https://www.simplypsychology.org/learning-kolb.html.*

Free tests can be used to determine student learning styles based on Kolb's Experiential Learning Theory. They can be scored automatically or by hand. Results could either determine a student's learning style using Kolb's Learning Styles or Honey and Mumford's variation on Kolb's Learning Styles. In August 2018, faculty members evaluated the following, with an eye toward assessing student learning styles:

Assessments to Determine Learning Styles		
Assessment	Format	Comments
1. Kolb's Experiential Model Best Fit Self-Assessment	4 questions Paper delivery Kolb's Styles	Administer in 5 minutes Results scored by hand Requires reviewing Kolb's Learning Style Descriptions first
2. Kolb Learning Style Inventory	80 questions Paper delivery Honey and Mumford variation	Administer in 15 minutes Results scored by hand Participants reported overthinking questions, some results skewed
3. Learning Style Quiz	24 questions Online delivery Honey and Mumford variation	Administer in 5 minutes Immediate results Feedback in color with student-specific results
4. Learning Style Inventory	40 questions Paper delivery Kolb's Styles	Administer in 30 minutes Results scored by hand Skewable format

These assessments may be located for use by going to:

1. https://wit.edu/lit/engage/kolb-learning-styles
2. http://www.bunbury.wa.gov.au/pdf/environment/u472/Appendix%2019%20U472%20Community%20Facilitator%20Kolb%20Questionnaire%20Final.pdf
3. http://www.emtrain.eu/learning-styles/
4. http://med.fau.edu/students/md_m1_orientation/M1%20Kolb%20Learning%20Style%20Inventory.pdf

15 students have been assessed to date. The learning styles indicated thereby may be the original Kolb styles or Honey and Mumford's styles. While the Kolb Learning Style Inventory seemed to be longer and presumably more thorough than the Learning Style Quiz, the results were the same. The Learning Style Quiz (henceforth referred to as the Quiz) was easier to administer, shorter, self-scoring, and resulted in an easily relatable set of graphics and descriptions. Further, it was chosen because it did not take much time away from normal technology-focused class activities.

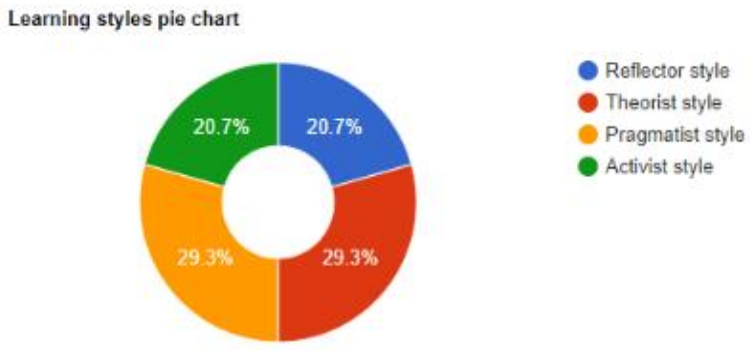

Figure 3. Sample result from the Learning Style Quiz.

If a different assessment is chosen for purposes of evaluating students, the results may need to be converted from Kolb's Learning Styles to Honey and Mumford's variation.

Learning Styles		
Kolb's	**Honey & Mumford's variation**	**Falls between 2 axes:** *1) Thinking or Feeling and 2) Watching or Doing*
Accommodating Style	**Activist**	**AE & CE (feeling & doing)**
Diverging Style	**Reflector**	**CE & RO (feeling & watching)**
Assimilating Style	**Theorist**	**AC & RO (thinking & watching)**
Converging Style	**Pragmatist**	**AC & AE (thinking & doing)**

With the students' dominant learning styles ascertained, preliminary examination of the attributes of those learning styles and corresponding activities, as shown in Figure 4, has begun.

All the activities associated with all four learning styles except paired discussions are interwoven into the curriculum and utilized during each of the Thursday events.

Learning style	Attributes	Activities
Activist	Activists are those people who learn by doing. Activists need to get their hands dirty, to dive in with both feet first. Have an open-minded approach to learning, involving themselves fully and without bias in new experiences.	• brainstorming • problem solving • group discussion • puzzles • competitions • role-play
Theorist	These learners like to understand the theory behind the actions. They need models, concepts and facts in order to engage in the learning process. Prefer to analyse and synthesise, drawing new information into a systematic and logical 'theory'.	• models • statistics • stories • quotes • background information • applying theories
Pragmatist	These people need to be able to see how to put the learning into practice in the real world. Abstract concepts and games are of limited use unless they can see a way to put the ideas into action in their lives. Experimenters, trying out new ideas, theories and techniques to see if they work.	• time to think about how to apply learning in reality • case studies • problem solving • discussion
Reflector	These people learn by observing and thinking about what happened. They may avoid leaping in and prefer to watch from the sidelines. Prefer to stand back and view experiences from a number of different perspectives, collecting data and taking the time to work towards an appropriate conclusion.	• paired discussions • self analysis questionnaires • personality questionnaires • time out • observing activities • feedback from others • coaching • interviews

Figure 4. From "Honey and Mumford," by R. Mobbs, n.d. Retrieved July 18, 2018, from https://www2.le.ac.uk/departments/doctoralcollege/training/eresources/teaching/theories/honey-mumford

During the four-hour event, the goal is to challenge students with a disorienting dilemma to motivate them to leave their comfort zones, think for themselves, enlist the help of others and solve a real-world networking problem. For a grade, students are required to identify abnormalities on the network with regard to network traffic and website, email, firewall, and Domain Name System (DNS) servers. Figure 5 is an example of a network abnormality; herein June 24, 2018, during the third class session, a senior student has used Wireshark to capture a DNS zone.

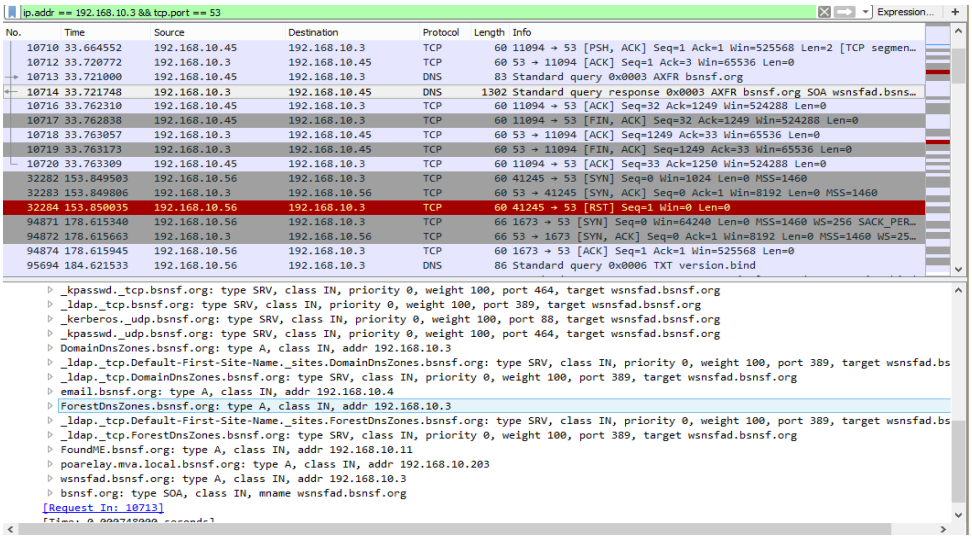

Figure 5. Network abnormality.

CLASS AND NETWORK SETUP

The instructor designs the network abnormalities for student discovery. Prior to the event, the class network is set up and between six and ten issues are in place to be identified during the event. They can include the following (as well as the scenario described under “Curriculum Design”):

- a network computer performing an Xmas scan on the network
- the door to the server room left unlocked
- a website redirector
- a DNS poisoning
- a rogue network access point

Beginning in the first hour, the instructor will start with a brief introduction of what is expected from the students. In this specific scenario, he tells students that they have been hired as cybersecurity analysis experts and have been called in to identify the current network abnormalities. The network is Class C, and each student has his own VMware server, Active Directory domain, and network analysis tools.

In addition, the instructor outlines the four class sessions: For the first hour, the students are to use their network analysis tools and look for abnormalities on the network. The students are not restricted in what they can use to locate these abnormalities. In the second hour, the students will start to confirm their findings with the instructor, often privately. During the third hour, the instructor will start to provide guidance and feedback as well as begin to confirm findings. For the last hour, the instructor will review how students located the issues and irregularities on the network. Finally, the student has to be able to define and document each issue and identify the proper course of incident response for that abnormality.

Figure 6 is an example from the third session. The instructor demonstrates how to perform a DNS zone transfer request. He then provides a comprehensive overview of this demonstration, in order for students to realize how to close this security gap.

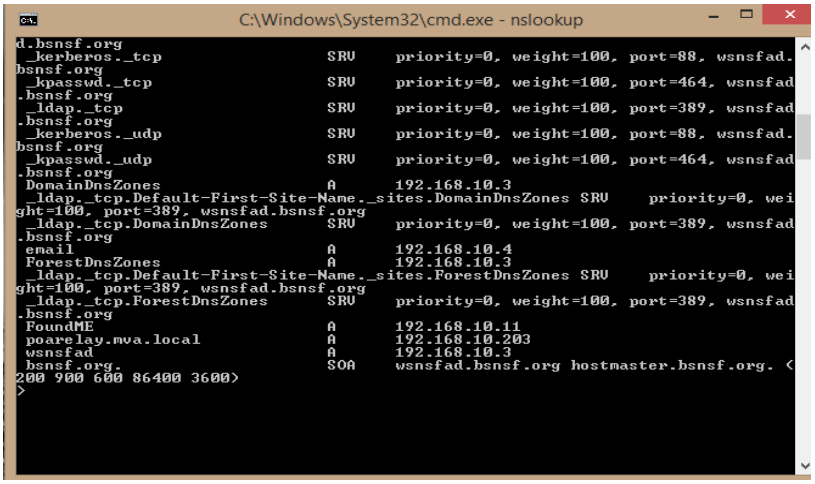

Figure 6. DNS zone transfer request.

Participants

The ten class participants attend a private, proprietary technical college. Each has completed all associate-level coursework to include fifteen semester hours aligned

to CompTIA certifications, i.e., A+, Network +, Security + and Linux+; 15 semester hours in Microsoft Configuration and Administration Courses aligned with Microsoft's Certified Solutions Expert (MCSE) certification; and twelve hours of Cisco Configuration and Administration coursework aligned with CCENT and CCNA certifications. Eighteen remaining semester hours include introductory computer programming and database courses, project management, professional development, and VMWare courses. During the Thunderhead Thursday events, these participants have either one or two final remaining semesters of courses that are aligned with the eight domains of the Certified Information Systems Security Professional (CISSP) certification. The five students who have two semesters left are considered the new, while the five remaining students have completed one of the remaining semesters and are considered more experienced and seasoned.

APPLYING KOLB'S STAGES OF LEARNING

When the new students first arrive, they are excited and ready to apply what they have been learning from associate-level courses. Their first such chance – i.e., experience – comes as they encounter hypothetical network abnormalities, as explained previously.

But when integrating into a class of students who are acquainted with network analysis tools such as Wireshark, those who are more or less uninitiated often experience befuddlement. Such feelings may be compounded when guests are present and asking questions. This is the point at which the disorienting dilemma comes into play, as illustrated by the following instructor-solicited feedback :

- Student 1: "Everything looks the same at first."
- Student 2: "I encountered struggle in the very beginning, as the only tool I had at my disposal was Wireshark, but I didn't even know how to use it. So, I was basically going through every single packet finding nothing because I didn't know about filters or what to look for."
- Student 3: "It was a lot to take in at first … .I struggled with everything that first night because I had never used anything like this before!"

After a few minutes, they sit quietly staring at their laptop screens. They continually check out ports in an attempt to isolate the issue. The instructor narrows the search down to the device that contains the issue, but students still are not able to identify it. The deep-space stare results from not being able to identify any abnormalities on the network, and this leads the student to begin self-examination and enter the next stage of learning. **Reflective observation** occurs when student begin to realize they are not alone in struggling to find abnormalities on the network. Some students begin to be discontented with the event.

- Student 1: "I didn't know what to do or even where to start. … I flopped like a fish out of water."
- Student 2: "The whole process in the beginning was very frustrating, because I had no idea what to look for or how to use Wireshark. Along with that, people kept saying they were finding things, but I had no idea how."
- Student 3: "Nothing really frustrated me, because I went in to this knowing I was ignorant of the tools."

Abstract conceptualization follows. Most of the students begin ask to their more seasoned peers how they are successfully finding abnormalities on the network. Following this stage is **testing**. Students begin to explore options, plan a course of action, acquire new skills and abilities, try new roles and then begin to build self-confidence.

- Student 1: "When people started sharing what they found, I was able to look for specific data and see what they were looking at."
- Student 2: "I waited patiently to hear from other people and discovered filters to use and also what to look for. … Once I filtered out all traffic and only wanted to see FTP, I was able to find the FTP server on the network and locate the shark pictures."
- Student 3: "I met success in logging into the host using FTP. My fellow peers (the new ones) would benefit from learning how I did this. It's good to share experience so we can all learn and push each other to do better."

Students are not required to complete the cycle in any particular order; as noted previously, they will enter and exit all of the stages.

OUTCOMES

Five students have graduated.

Five students are placed in jobs from their field of study.

One CompTIA Certified Ethical Hacker Certification was attempted and passed.

Networking

A number of guest speakers, companies, and graduates have joined the class during this event. A local technology support company occasionally sends personnel, who enjoy meeting students and learning how their curriculum is designed. Some discussions of utilizing Federal Work-Study funds for internships are underway. A graduate brought additional equipment to be incorporated into the scenarios. Law enforcement officers have come and spoken to the class about events that they experience related to working in cybersecurity.

Excitement and Expertise

The students are always excited and look forward to this weekly event. Morale is high because students become passionate about their ability to solve problems. Students build strong skills over time, and the event process is demonstrating to them the development and maturity of those skills.

- Student 1: "It is a new way to learn and very effective. … Full immersion worked (well). … (Next Thursday night, I will) use what I learned and think outside the box."
- Student 2: "It was great to see this in action, instead of what I've seen in the movies. … Knowing how to use filters in Wireshark is definitely key, since going through 100,000 packets one by one will get you nowhere. … Doing a more detailed inventory (of everything on the network) will allow me to filter out IP addresses/devices that we do not know of."
- Student 3: "I liked how each hour revealed a little more of the mystery to you. … A key takeaway for me was that there are a plethora of things you have to be keeping track of, and that you need to know your network very well so you can identify what belongs and what doesn't. … (Next) Thursday night, I will already know things to look for … instead of jumping in completely blind."

Some of the scenarios have resulted in students learning more about a particular tool than required for class. For example, one of the students has become the class's unofficial Wireshark expert.

CONCLUSION

Transformation indeed has occurred. By employing the disorienting dilemma and the mix of activities from each of the learning styles, the Thunderhead Thursday event nudges the students through each learning cycle and relates to each student's dominant learning style as well as his recessive learning styles. The environment takes the students out of the "instructorcentric" classroom by placing them in an experience that causes them to perform with their peers or give up (fight-or-flight response). Strong outcomes in learning are achieved. The process forces them to be autonomous in their search for their solutions to problems. The instructor and their classmates guide them toward solutions. Dynamic relationships with the instructor and the team are realized and strengthened while using real-world scenarios.

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