Active Learning Techniques for Preparing NeuroIS Researchers

Arjan Raven[1] and Adriane B. Randolph[2(✉)]

[1] Department of Management Information Systems, Temple University, Philadelphia, PA, USA
[2] Department of Information Systems and Security, Kennesaw State University, Kennesaw, GA, USA
arandol3@kennesaw.edu

Abstract. The field of neuroIS is rapidly evolving, and there is a need to create a research and work force at various levels of the academy ranging from undergraduate students to professors. Motivation is not an issue with neuroIS as students are typically excited to learn, but how do we teach them the skills they need to succeed? Active learning is a pedagogical technique that has a natural fit with neuroIS. It focuses on the higher levels of learning that are essential in the field. This paper is an introduction to active learning for the benefit of the neuroIS community. It discusses examples of what can be done as well as challenges that need to be overcome.

Keywords: Active learning · NeuroIS tools · Pedagogy

1 Introduction and Motivation

Although neuroIS tools are being used to examine "neuro-education" to better understand student learners and their cognitive processes [1–3], there is also a need to examine the education of neuroIS researchers. This becomes even more important as the need for people with neuroIS skills is increasing and as the required skill base is expanding. The neuroIS community may benefit from educational pedagogy particularly well-suited to teach the necessary skills through active learning [4].

NeuroIS researchers and workers need to understand the different technologies such as functional magnetic resonance imaging (fMRI), electroencephalography (EEG), skin conductance response (SCR), functional near-infrared (fNIR) imaging, and eye tracking. They need to have experience with some of the equipment, but they also need to understand the intricacies of brain-based interface design as they consider the development of neuroadaptive interfaces [5]. Perhaps the most important skill they need is to be able to learn about new developments in the field and to quickly adapt new technologies. Any equipment and software they train on today may be replaced within a few years.

Riedl and Leger have created a foundational textbook that can be used as a corner stone for courses in neuroIS [6]. With the publication of the textbook, a reference syllabus was created that creates a basic structure for a course built around the book. As the authors point out in their discussion of the syllabus, neuroIS is a younger field that is

F. D. Davis et al. (Eds.): NeuroIS 2021, LNISO 52, pp. 172–177, 2021.
https://doi.org/10.1007/978-3-030-88900-5_19

rapidly developing [7]. It can be difficult to create course material and assignments and to keep all the material up-to-date from semester to semester. In the five years since the publication of the book the fundamental science has not changed, but equipment has continued to develop and a plethora of applications of neuroIS has emerged, including even brain-controlled toys. Recently published articles and newspaper stories can be used to teach the latest developments.

The combination of the syllabus, textbook, and recent materials provide the basic structure for a neuroIS course, but they do not provide guidelines for how they can be used in the courses. The aim of this paper is not to update the reference syllabus but to discuss what educational techniques can be used in courses on neuroIS. Teaching neuroIS is essential, but it is also challenging. Perhaps the biggest challenge is to create lab time for every student so that they can individually get hands-on experience. A pedagogical development that has been gaining interest over the years and now seems to have real momentum is active learning [8]. Here we explore how an active learning framework may be especially relevant for neuroIS.

2 Active Learning as a Pedagogical Technique

It would be ideal if neuroIS classes could be taught in an active lab where every student has access to all the tools and can work alongside experienced researchers [5]. However, the equipment is expensive and the number of neuroIS scientists is limited. At the same time, students must learn how to work directly with brain-based interfaces and how to develop software. The closest simulation of real-life neuroIS situations is to create an active learning classroom environment for the students.

There are many ways in which students can perform activities that will give them a deeper and more practical understanding of the material. Bonwell and Eison [8] (p. iii) define strategies to promote active learning as "…instructional activities involving students in doing things and thinking about what they are doing…They must read, write, discuss, or be engaged in solving problems. Most important, to be actively involved, students must engage in such higher-order tasks as analysis, synthesis, and evaluation."

These levels of tasks and learning are classically examined in education. Bloom's Taxonomy [9, 10] identifies three lower levels of learning (Remember, Apply, Understand) as well as three higher levels (Analyze, Evaluate, Create). Active learning is a great way to reach the higher levels of learning. While the taxonomy addresses the learning goals, active learning can be seen as a guide to the methods to attain these goals.

Building on Bonwell and Eison's work, Prince [11] (p. 223) defines active learning as "any instructional method that engages students in the learning process. In short, active learning requires students to do meaningful learning activities and think about what they are doing." He notes that meta-studies on active learning at times show conflicting results and notes a need to more clearly distinguish between the different types of active learning. He identifies collaborative learning, cooperative learning, and problem-based learning as important subsets. His investigation of the different types of active learning identifies extensive support for the success of active learning. In a 2014 study, Freeman et al. [12] conducted a meta-analysis of 225 studies in science, engineering, and mathematics, and found that student performance improved by almost half a standard deviation in active learning vs traditional lecturing.

Active learning is applied in many different fields of study that are relevant for neuroIS courses. It is, for instance, considered to be beneficial for medical students in psychiatry [13]. In Information Systems (IS) education, active learning has been used for business intelligence education. A recent empirical study discusses collaborative active learning resulted in better performance, more reflection, and better retention of the material [4]. Two studies discuss how IS core courses at different universities are redesigned to include more active learning. Both articles found mixed results from the changes [14, 15].

3 Application of the Active Learning Approach at Kennesaw State University

There is an evolving set of learning objectives in neuroIS following as the field is evolving [5, 16]. It is a highly specialized field where students need to get the hands-on experience of working with the tools. There is a large tacit knowledge component to it. For example, students need to be able to look at the data and recognize a pattern that indicates that an external signal is interfering and bleeding into the main signal, as with EEG. They also need to know what the current hardware and software are and be able to quickly learn new technologies.

To have a stronger grasp of the underlying concepts and to encourage higher-level learning, students should be encouraged to see the technology in action by offering demonstrations or field trips and engagement with the material. Expect that many students will want to try the technology first-hand despite stated risks for an fMRI scan or inconvenience of gel in one's hair as with most EEG systems. In classes about technology, it can be a problem to motivate the students, but in neuroIS, we have the luxury of students who tend to be highly-motivated and are excited about the work.

An introductory course on neuroIS was taught three times by the second author, at Kennesaw State University (KSU). It was offered as an upper-level elective targeted for undergraduate MIS majors. The last time this was taught was in the fall of 2015, and at that point the Riedl book [6] was not yet available. Instead, the course relied on academic articles and media reports. The course design overlaps with that of the reference syllabus [7], but did not include discussions of measurement of the peripheral nervous system, oculometry, facial muscular movement, or hormones. It also did not include a discussion on how to establish a neuroIS lab, but the BrainLab at KSU was used as an example of what a lab could look like and had been established for eight years at the time. Table 1 presents examples of activities from a neuroIS class taught by the second author. The activities are mapped to their associated learning objective. They range from passive to increasingly more active [17].

There are limitations to how active the assignments in a class can be. Lab space is often physically limited, and there especially is a dearth of equipment unless a space has received deep funding support. Students have to take turns working with the neurophysiological equipment. Presently, there are additional concerns regarding safety during a pandemic although protocols have been recommended by vendors of neurophysiological equipment such as by Cortech Solutions in

Table 1. NeuroIS class activity examples

Learning Objective	Activity
Identify parts of the brain utilized for cognitive processing and control	**Passive:** Listen to guest lecture from a professor in cognitive neuroscience. Even though the material lecture was very interesting, the students did not work with the material they were learning
Compare different control-abilities of end-users	**More Active:** Read, review, and discuss academic papers on individual differences and neural control. In reviewing the material the students were asked to critically review what they were reading. In the next step they discussed their observations and thus were exposed to different viewpoints
Discuss applications for using brain-imaging techniques to assess human mental states	**Yet More Active:** Visit local hospital to see an fMRI in action. The second author organized a site visit in which the students were able to see fMRI as it is used in a clinical setting. They interacted with the medical staff, and were able to compare this real-world setting with what they had read about
Design and demonstrate useful integration of information systems with novel input from the brain	**Yet More Active:** Conduct case analysis, design, or experiment in teams and present to the class with panel of expert visitors. For this project component of the class the students had a choice of activity. For instance, a student group designed an interface for a system that allows a locked-in patient to change settings in the environmental controls in their home. The project had the students apply Bloom's lower-level skills as they studied existing systems as well as the higher-level skills while they created the new interface
Identify current technologies that incorporate neural or psychophysiological recordings	**Yet More Active:** Participate in technology demonstrations in-class. In this kind of setting students are either subjects or conduct the demonstrations. In both roles they get first-hand experience of doing neuroIS research work in a lab setting. The activities integrate what they have more passive learned through reading and observation with the physical experience of using the equipment

the United States (https://cortechsolutions.com/special-considerations-for-human-neuroscience-research-in-the-midst-of-the-covid-19-pandemic/).

The problems become even more challenging in on-line classes where equipment may have to be sent from student to student. Then, the student has to be their own subject. To achieve this, a trade-off often must be made between using multiple, less-expensive devices that may be considered less robust versus one or a few more research-grade devices [18]. This tradeoff may be made inconsequential depending on level of focus for the outcomes of the class. In addition to measurement equipment, there is a need for software tools that can be used to design a brain-computer or neuroadaptive interface.

4 Conclusion

Active learning is a very effective way to help students achieve the higher levels of learning in Bloom's taxonomy. The need for neuroIS classes is increasing, which means that there will also be more innovation in teaching methods. As a field, we can share more of those methods through case studies, best practice descriptions, and research on the pedagogy of neuroIS. Furthermore, we can help each other identify affordable measurement equipment and software development tools that still meet our learning needs. As more neuroIS courses are outlined and offered, they are being done so by researchers from established labs as well as newcomers. This paper helps codify a method of how new researchers in the field may obtain the knowledge beyond what are the details of that knowledge.

References

1. Charland, P., et al.: Measuring implicit cognitive and emotional engagement to better understand learners' performance in problem solving. Zeitschrift für Psychologie **224**(4), 294 (2017)
2. Charland, P., et al.: Assessing the multiple dimensions of engagement to characterize learning: a neurophysiological perspective. J. Vis. Exp. JoVE 101 (2015)
3. Randolph, A., Mekbib, S., Calvert, J., Cortes, K., Terrell, C.: Application of neurois tools to understand cognitive behaviors of student learners in biochemistry. In: Davis, F.D., Riedl, R., vom Brocke, J., Léger, P.-M., Randolph, A., Fischer, T. (eds.) Information Systems and Neuroscience. LNISO, vol. 32, pp. 239–243. Springer, Cham (2020). https://doi.org/10.1007/978-3-030-28144-1_26
4. Romanow, D., Napier, N.P., Cline, M.K.: Using active learning, group formation, and discussion to increase student learning: a business intelligence skills analysis. J. Inf. Syst. Educ. **31**(3), 218–231 (2020)
5. vom Brocke, J., et al.: Advancing a neurois research agenda with four areas of societal contributions. Eur. J. Inf. Syst. **29**(1), 9–24 (2020)
6. Riedl, R., Léger, P.-M.: Fundamentals of NeuroIS. Studies in Neuroscience, Psychology and Behavioral Economics. Springer, Berlin, Heidelberg (2016)
7. Riedl, R., Léger, P.-M.: Neuro-Information-Systems (NeuroIS). A.f.I. Systems (2016). EDUglopedia.org
8. Bonwell, C.C., Eison, J.A.: Active Learning: Creating Excitement in the Classroom. 1991 ASHE-ERIC Higher Education Reports. ERIC (1991)

9. Anderson, L.W., Bloom, B.S.: A taxonomy for learning, teaching, and assessing: a revision of Bloom's taxonomy of educational objectives. Longman (2001)
10. Bloom, B.S.: Taxonomy of Educational Objectives. vol. 1: Cognitive Domain, no. 20, p. 24. McKay, New York (1956)
11. Prince, M.: Does active learning work? A review of the research. J. Eng. Educ. **93**(3), 223–231 (2004)
12. Freeman, S., et al.: Active learning increases student performance in science, engineering, and mathematics. Proc. Natl. Acad. Sci. **111**(23), 8410–8415 (2014)
13. Sandrone, S., et al.: Active learning in psychiatry education: current practices and future perspectives. Front. Psychiatr. **11**, 211 (2020)
14. Lavin, A., Martin, M.-C., Sclarow, S.: Radically redesigning introductory MIS large-scale lectures: creating enhanced learning environments. In: Proceedings of the 2018 AIS SIGED international Conference on Information Systems Education and Research, Philadelphia (2019)
15. Riordan, R.J., Hine, M.J., Smith, T.C.: An integrated learning approach to teaching an undergraduate information systems course. J. Inf. Syst. Educ. **28**(1), 59–70 (2017)
16. Riedl, R., et al.: A decade of NeuroIS research: progress, challenges, and future directions. ACM SIGMIS Database DATABASE Adv. Inf. Syst. **51**(3), 13–54 (2020)
17. Randolph, A.B.: Learning what is top-of-mind: a course on neuro-information systems. In: 11th Pre-ICIS Workshop on HCI Research in MIS. 2012: Orlando, FL (2012)
18. Riedl, R., Minas, R.K., Dennis, A.R., Müller-Putz, G.R.: Consumer-grade EEG instruments: insights on the measurement quality based on a literature review and implications for NeuroIS research. In: Davis, F.D., Riedl, R., vom Brocke, J., Léger, P.-M., Randolph, A.B., Fischer, T. (eds.) NeuroIS 2020. LNISO, vol. 43, pp. 350–361. Springer, Cham (2020). https://doi.org/10.1007/978-3-030-60073-0_41