ETSI Experimental Design and Research Training Program

Learning Objectives

While teaching of science in traditional classroom settings exposes student to facts and concepts, and guides them towards a better understanding of natural phenomena, science is actually the process of testing hypotheses in order to gain novel insights. Numerous studies of scientific learning have demonstrated that engaging students in the process of doing science increases interest in science and helps students have a deeper understanding of material. Based on these findings, the ETSI sustainability phase includes significant investment in helping the monastics design and execute authentic research projects. Objectives for the Experimental Design and Research Training Program include:

- enhance the monastics' understanding of key steps in the scientific process, including defining questions, experimental design, reiterative hypothesis testing, data analysis, and scientific presentation.
- demonstrate how experiments can be leveraged as a mechanism to teach science.
- facilitate the monastics' development and execution of research projects related to questions important to them and to their community.
- enhance monastics' interest in science and identity as scientists.
- teach the monastics technical skills required to execute research projects, particularly in the domain of cognitive neuroscience

Overview of Training Approach

There are three models for incorporating research into science education. The first is for instructors to design laboratory exercises that demonstrate particular phenomena or test hypotheses that has previously been tested. While this approach can increase learning, numerous studies have demonstrated that authentic research experiences, in which students conduct research to study questions for which the answer is not known, are more likely to increase students' interests in science and to bolster their identity as scientists. Authentic research experiences can follow one of two approaches. In the first approach, the instructor(s) define the question and often all students within a course work together to conduct experiments to test that question. Under this approach, the instructor may come up with the experimental design or may guide the students to develop their own experimental designs. In the second approach, instructors guide students to define their own authentic research questions and to develop their own experiments. It is not known clear whether one approach is better than another. Here, we use the three-year training model to transition from a more guided experience to a less guided experience.

Specifics of Course Design

Year 1. Authentic Group Research Experience

In the first year of the program, instructors with diverse science backgrounds will lead a training course in the scientific method and experimental design. The students will also be taught the necessary techniques to address a research question pre-selected by the instructors. While pre-selected, the answer to the research question will be unknown. The instructors will guide the students through the process of designing an experiment, to be conducted at the participating

monasteries over the course of the next three to six months, to test the question. While the question has not yet been selected, leaders in the sustainability phase have discussed the possibility of focusing the question on how sleep patterns of the monastics influence memory and cognition.

Year 1 Foci

- *The scientific method and experimental design.* This will be taught by having the monks design a basic experiment that is aligned with the curriculum covered in the ETSI introductory biology course. Thus, the monastics may be able to use this experimental lesson in their teaching.
- *Defining novel questions and designing experiments.* This will include an introduction to finding and evaluating scientific literature, developing questions based on previous research and observation, experiment replication and experimental controls
- *Training in specific techniques and instruments needed to test defined question, with focus on cognitive neuroscience methods.* Should we focus on investigation of sleep, this will include training in survey design, mechanisms to collect behavioral and sleep data, tests for memory, and tools available to assess brain activity. Special attention will be given to training the monastics in EEG methods and experimental design. The monastics will help the set-up and build an EEG laboratory at the monastery, which will provide them with a foundational knowledge of cognitive neuroscience equipment. They will also receive training in EEG methodology, signal processing, and analysis.
- *Preliminary data collection and evaluation, and refining experimental designs.* We will establish protocols to consolidate data using Google tools (e.g., forms and sheets). Consolidated data will facilitate discussions using zoom and other web platforms when instructors are not available locally.

Year 2. Data Analysis and Small Group Project Development

In year 2, we will analyze data as a large group and have small groups from each monastery and nunnery give an overview of their results and questions that arise from those results. Then, we will shift to introducing students to a broader array of techniques that can be used to collect data relevant to more individualized experiments. Finally, with these techniques as a springboard, the instructors will guide the students through exploration of potential research topics and finalization of experimental designs. To facilitate implementation of research, monastics will work together in small groups from their own monasteries and nunneries, or monasteries and nunneries near their own.

Year 2 Foci

- *Continued training in cognitive neuroscience methods.* Building on the Year 1 training, monastics will continue learning skills in EEG and cognitive neuroscience. Students will gain exposure to more advanced EEG methodologies and become familiar with other cognitive neuroscience methods, including event-related brain potentials (ERP). We will also explore the possibility of training in brain imaging techniques (e.g., structural and functional MRI) at nearby facilities, if available.

- *Data visualization and analysis, using data from Year 1 project.* The focus of the year 1 research project will be selected such that we can collect different types of data that can be visualized using different graphical approaches. We will introduce one to two basic statistical tests (e.g., chi-square tests, t-tests).
- *Exposure to available techniques and tools.* The techniques and tools available will in part depend on the final set of instructors selected to guide the course, and of course will be constrained by what can be made locally available. Based on expertise of identified instructors for the sustainability phase, and based on scientific interests of monastics who participated in the research training pilot, techniques will include survey design, data collection on heart rate and other basic physiological parameters, mosquito identification, measurements of water quality, and deeper training in EEG.
- *Defining questions and experimental approaches.* With guidance, each group will explore research interests and brainstorm potential questions. Upon defining a question, students will then design experimental designs, which will be refined with help from instructors. Students will write up protocols for data collection to be used over the course of the next year and will present their research plans to the group.
- *Preliminary data collection and evaluation, and refining experimental designs.*

Year 3. Continuation of Small Group Projects, Final Presentations

- In year three, students will focus on further refining and extending their projects and will develop presentations of their research results to be presented to each other and to young students in local schools. They will be provided an opportunity to deepen their training in cognitive neuroscience and/or broaden their research training to other topic areas in physiology, biology, and ecology, depending on available resources. Training in cognitive neuroscience will include exposure to more advanced signal processing techniques and experimental methodologies for EEG/ERP and continued training in functional and structural brain imaging.

Year 3 Foci

- *Data visualization and analysis*
- *The iterative process of science, and designing follow-up experiments*
- *Scientific presentations*
- *Setting the foundation for independent research projects.* A goal of year three is to help set the foundation for future independent research projects by the monastics. This will include establishing ongoing collaborations with faculty who can consult on projects, developing the technical and methodological skills to carry out research projects, and continued training in data analysis.