Department of Psychology, College of Liberal Arts
Rochester Institute of Technology

Provost's Learning Innovation Grant (PLIG) for 2019

FINAL REPORT

Esa Rantanen, Ph.D., CPE

August 29, 2020

Abstract

This grant allowed for a redesign of the PSYC 714 "Graduate Engineering Psychology" course, offered by the Department of Psychology about every two years since 2013, for online delivery. The grant was awarded on March 29, 2019. Full Project Plan report was submitted on Aug. 16, 2019. The majority of the course redesign work was completed during the fall semester 2019 (2191), including creation of several software programs to support the lab exercises designed for the course. The Preliminary Findings report was submitted on Jan. 10, 2020, and the PSYC 714 course was offered online in the spring semester of 2020 (2195) as a "pilot" of the redesign. The course ran successfully through the semester, and being online, was not impacted by the COVID-19 pandemic that resulted in closing of RIT's campus and moving of all classes online after the extended spring break on March 23, 2020. Other events related to this grant (Preliminary Findings Roundtable and PLIG Showcase) were canceled. The final report deadline was extended from August 21 to August 31, 2020. This document details the course design features and is meant for broad distribution and to serve as a model for other graduate courses that may be moved online at RIT. Moreover, the PSYC 714 course is required for the Advanced Certificate in Engineering Psychology (ENGPSY-ACT) at RIT. This documentation of the development of this course will hopefully allow two other required courses in the ENGPSY-ACT program be redesigned for online delivery. This would effectively make the entire ENGPSY-ACT an online program, as there already are several online graduate courses offered at RIT that may serve as electives in the program.

Contents

1 Engineering Psychology

1.1 A Brief History

Engineering psychology evolved as a distinct discipline during and after World War II. Three forces may be identified behind this [1]. First, practical needs that arose from the accelerating advancement of technology, which was a direct result of the war effort.

Second, technological advancements were particularly pronounced in the aviation domain, where aircraft speed, capabilities, and complexity increased at an unprecedented rate. This resulted in unacceptable accident rates and loss of life before the pilots ever saw combat. It was no longer possible to fit the human to the machine through selection and training, but human capabilities and limitations had to be considered in the *design of the machines*.

Third, linguistic developments were brought about by the combined effort of both engineers and psychologists to address the novel human-machine interface problems. The role of the human operator was acknowledged as that of a system component and human behavior was described in similar terms as the systems they were interacting with. Thus terminology and concepts common in electrical and systems engineering (e.g., channel capacity, feedback, optimal control, etc.) replaced the stimulus-feedback language of behavioral psychology and further facilitated the integration of engineering and psychology for the design and evaluation of human-machine systems.

1.2 Terms and Definitions

To define engineering psychology as a discipline it is important to distinguish it from both psychology and engineering as well as from several other, closely related, disciplines. Although there is a relationship between applied psychology and engineering psychology, there is also an important difference: Where applied psychology seeks to control and influence people, the goal of engineering psychology is the design of a better machine. Although this at the time was a very non-traditional objective from the psychologists' point of view, psychology made substantial contribution to the design of machines: Knowledge of human variability and methods of dealing with it, factors engineers were not used to accounting for. Thus the role of the engineering psychologist in machine design is thus both that of a scientist, seeking knowledge of human behavior, capabilities, and limitations for engineers to use, and that of a technologist, actively participating in the design of human-machine systems [2].

Although engineering psychology shares the practical orientation with applied psychology, the methods employed in research of human-machine systems are primarily those of experimental psychology [3]. To differentiate engineering psychology from applied experimental psychology, then, one must again consider the specific domain of applications of engineering psychology, the human-machine systems. To further underscore the unique nature of engineering psychology, the discipline was accorded a divisional status (Division 21) by the American Psychological Association. The mission for Engineering Psychologists is defined by APA as "to promote research, development, application and evaluation of psychological principles relating human behavior to the characteristics, design and use of environments and systems within which people work and live" (American Psychological Association).

Engineering psychology differs from the closely related discipline of *human factors*, or *human factors engineering*, in two important aspects. On one hand, human factors is a much broader discipline which encompasses such diverse sub-disciplines as anthropometry and biomechanics [4]. The same is true for *ergonomics*, a term commonly used in Europe and essentially synonymous with human factors, as the discipline is referred to in the United States. Engineering psychology, true to its roots in psychology, is concerned predominantly with the information processing aspects of human performance. On the other hand, human factors can be seen as a purely applied discipline, while engineering psychology, albeit motivated by applications in human-machine systems design, is also concerned with more basic research [1]. The ultimate goal of human factors is to improve system design, not to seek understanding of human behavior, whereas “the aim of engineering psychology is not simply to compare two possible designs for a piece of equipment, but to specify the capacities and limitations of the human, from which the choice of the better design should be deducible directly” [5, p. 178].

The cognitive focus of engineering psychology has recently become increasingly pronounced. This reflects the shift of interest towards cognition in psychology in general but also the new demands increasingly complex systems place on the operators. The emphasis on cognition is today the main scientific force driving application efforts [6]. This fact is underlined by the emergence of such disciplines as *cognitive engineering* or *knowledge engineering*. These disciplines, however, are too young to have their own, fully developed, identity and they cannot be adequately distinguished from the more established engineering psychology.

Because the main area of application for engineering psychology is systems design and evaluation, a quantitative approach to the description of human behavior is imperative. These efforts have benefited substantially from the influence of the traditional engineering disciplines [2, 1]. In addition to the methods of experimental psychology, mathematical modeling is an essential tool used by engineering psychologists [7]. Extensive reviews of the various modeling approaches are provided by [8, 9, 10, 11].

2 Background of Course Redesign

2.1 Project Objectives

This project was aimed at developing and delivering an online graduate course, PSYC 714 “Graduate Engineering Psychology”, which is part of an Advanced Certificate (AC) program, the Advanced Certificate in Engineering Psychology (ENGPSY-ACT). Thorough documentation of the development of this course is aimed at allowing two other required courses in the ENGPSY-ACT program (PSYC 712 “Graduate Cognition” and PSYC 715 “Graduate Perception”) to be redesigned for online delivery as well. This would effectively make the entire ENGPSY ACT an online program, for there already are several online graduate courses offered at RIT that may serve as electives in the program.

2.2 The Problem

The ENGPSY-ACT was approved by Academic Senate on January 25, 2013. Since then, several graduates from the MS in Experimental Psychology (EXPSY-MS) have earned the AC as part of their regular MS curriculum. The ENGPSY-ACT was also designed to benefit students in other graduate programs at RIT, specifically in Industrial Engineering (ISEE-MS) and Human-Computer Interaction (HUMCOMP-MS), but also professionals working in industry who are unable to leave their jobs to enroll in a graduate program but would nevertheless like to burnish their credentials. However, very few people outside the EXPSYC-MS program have had access to it. The primary problem is scheduling. In particular, the three required courses have historically been scheduled in conflict with courses in the other graduate programs at RIT, and at times of the day when industry professionals are unable to come to campus to attend them.

2.3 Significance

Converting the entire ENGPSY-ACT program to online format would substantially improve its accessibility to students from diverse disciplines as well as to people outside RIT. The proposed project would also create a procedure and template for conversion of the other two required courses in the ENGPSY-ACT program, which would allow for the entire program be offered online. A redesign of a course that is part of a larger program will also allow for coordination of the contents of the courses in the program so that they are complementary and form a coherent whole. Finally, the course was redesigned to meet an external standard, that of the Core Competencies of the Board of Certification for Professional Ergonomics.

2.4 Integration with RIT Priorities

Online offering of the PSYC 714 course (as well as the PSYC 712 and 715 courses) is aligned with the RIT strategic goal to develop and execute new flexible course delivery models by offering more online options in graduate programs. A program such as the ENGPSY-ACT will serve as outreach to nontraditional students. This project may also serve as a first step in the process of making the ENGPSY-ACT part of RIT's MicroMasters program.

3 Course Development Plan

3.1 Creativity and Innovation

There are four aspects of the proposed course conversion that make it novel and innovative:

1. The course will maximize the affordances of its delivery medium, that is online using RIT's course management system myCourses. This is first and foremost a theoretical question, and as such it must be re-examined as data on student learning become available each time the course is offered.
2. The course contents reflect my research over past 8 years on the knowledge and skills expectations for new human factors/ergonomics (HF/E) professionals (engineering psychology is a subdiscipline of HF/E) [12, 13, 14, 15, 16, 17, 18].
3. The course contents were designed to meet an external standard, that of the Core Competencies as defined by the Board of Certification for Professional Ergonomics (BCPE). The goal is to develop the courses in the ENGPSY-ACT to meet the criteria for a professional certification by designing the courses according to the published core competencies to help students earn independent certification of their competence upon completing the 5 courses required for the ENGPSY-ACT. This course redesign was the first step towards that goal.
4. The research for and development of the engineering psychology course within the this project was extensively documented. This documentation is designed in such a way that it will serve as a handbook and a template for similar conversion of other courses, first the other two required courses in the ENGPSY-ACT program (PSYC 712 "Graduate Cognition" and PSYC 715 "Graduate Perception"), but conceivably also serving all the faculty at RIT who may wish to convert their courses into online format.

These aspects of the course development are elaborated below.

3.2 Course Topics

The course covers the most fundamental topics of engineering psychology in multiple ways, through mini-lectures, reading assignments, online discussions, and lab exercises. The topics are:

1. Engineering psychology discipline
2. A model of human information processing
3. Cognitive task- and work analysis (CTA, CWA)
4. Signal Detection Theory (SDT) and Fuzzy SDT
5. Information theory
6. Models of attention
7. Spatial cognition, navigation
8. Manual control; discrete control (Fitts' Law) and continuous control
9. Augmented reality
10. Language and communications
11. Memory

12. Skills, Rules, and Knowledge (SRK) framework
13. Situation Awareness (SA)
14. Decision making, normative models
15. Information processing model of decision making
16. Naturalistic Decision Making (NDM)
17. Selection of action
18. Human error
19. Human Reliability Analysis
20. Multitasking and time-sharing
21. Mental Workload

3.3 Maximizing Affordances of Online Delivery

The working hypothesis in the development of this course is that an online course will occupy a place within a space (a tetrahedron) bounded by four primary learning methods at the vertices (see Fig. 1) and that given the affordances and constraints of the online format, an optimal point may be defined for the course. Hypothetically, although an online course will involve some lecturing (videos) and one-on-one mentoring with direct interactions with the instructor (online discussions), learning will be heavily weighted towards self- and group learning. Therefore, the course design should maximize the benefits afforded by these learning methods.

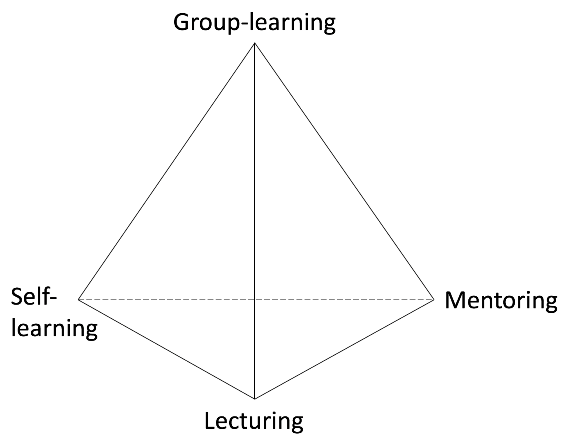

Figure 1. A hypothetical learning space with four main learning methods occupying the vertices of a tetrahedron, representing a learning space. Hypothetically, an optimal point for online learning may be found within this space.

There are two specific affordances of online format that were in the focus of the course redesign. First, because the course involves several lab exercises, it very well meets the definition of active learning. The labs require the students think through the theoretical underpinnings of each topic covered, test their understanding of the theory by selecting and manipulating appropriate independent variables and predicting the effect(s) on relevant dependent variables and measuring them. The labs also require development of the technical skills of experimental design, including control of extraneous variables, and data collection and analysis. Finally, the students will learn to communicate their findings in a clear and persuasive manner in lab reports. The challenge is to coach students to perform the labs and facilitate group learning through effective interactions with their classmates in an online environment. Second, writing skills are inherently important in an online course where most of the communication must happen asynchronously in writing [19]. With at least 7 short writing assignments (technical lab reports) the students will also work on a long paper assignment. which will have the format of a research proposal on a topic of their choice but relevant to the general course theme (engineering psychology) and based on their review of relevant literature [20].

3.4 Design for Periodic Redesign

As the knowledge and skills expectations for new HF/E professionals are constantly changing, tracking the trends in these in the workplace is an ongoing activity. Therefore the course design must accommodate periodic revisions to the knowledge and skills it is meant to impart to students. Such flexibility was a design criterion for this course, afforded by its modular structure.

3.5 External Standard

The course contents were designed to meet the Core Competencies as defined by the BCPE. The mission of the BCPE is to provide ergonomics certification to protect the public, the profession, and its professionals by assuring standards of competency and advocating the value of certification. There are two levels of certification, professional and associate, and three designations reflecting the certificant's primary area of competence. The associate level is seen as an optional, temporary, stepping stone to the professional level, and as such, and appropriate standard and criterion for the ENGPSY-ACT. In other words, the goal was to develop the courses in the ENGPSY-ACT to meet the criteria for a professional certification by designing the courses according to the published core competencies. Not only do such criteria provide external validation for the advanced certificate offered by RIT but also help students earn independent certification of their competence upon completing the 5 courses required for the ENGPSY-ACT.

The current BCPE core competencies are as follows, in three categories:

1. Analyze
    - 1.1. Conduct user research and/or assessment to identify, document, and prioritize requirements for individuals and groups to achieve their goals
    - 1.2. Identify and employ relevant organizational factors impacting individuals and groups interacting within an organization, to produce recommendations to enhance quality of work life, safety, effectiveness and efficiency
    - 1.3. Identify and measure the relevant physical, physiological and biomechanical aspects of individuals and groups performing their activities in their environments, with particular reference to health, safety, comfort and effectiveness and efficiency
    - 1.4. Identify cognitive, behavioral and social characteristics of individuals and groups that impact health, wellbeing, safety, performance, quality of life, attitudes, value belief systems, and motivation
    - 1.5. Identify and apply methods of evaluation of cognitive aspects of human-technology interfaces to reduce human error, optimize mental workload, and enhance health, comfort, safety, effectiveness and efficiency Identify and apply methods of evaluation of physical aspects of human-technology interfaces to reduce human error, optimize physical workload, and enhance health, comfort, safety, effectiveness and efficiency
    - 1.6. Identify and analyze training and educational aspects of human-technology interfaces to enhance health, comfort, safety, effectiveness and efficiency
2. Design
    - 2.1. Apply ergonomic principles and data appropriate to developing and fulfilling a set of requirements to achieve a safe, usable, effective, and efficient human centered design
    - 2.2. Design the hardware product, which includes functions, information displays, interactions, communication modalities etc., within the constraints and capabilities, and context to enable individuals and groups to accomplish a particular set of goals

2.3. Design the software product, which includes functions, information displays, interactions, communication modalities etc., within the constraints and capabilities of the hardware and the context to enable individuals and groups to accomplish a particular set of goals
2.4. Design tasks within human capabilities and limitations, and the workplace context to enable individuals and groups to accomplish a particular set of goals, and manage stress and fatigue
2.5. Design jobs using systematic procedures, principles, and techniques in developing and combining tasks into jobs to make them safe, efficient, effective, and motivating, to better utilize human capabilities, and manage stress and fatigue
2.6. Design the organization within human capabilities and limitations, and the social context to enable to accomplish a particular set of goals, and manage stress and fatigue
2.7. Design the environment, within human capabilities and limitations, and the wider context to enable to accomplish a particular set of goals, and manage human stress and fatigue
2.8. Design training and educational aspects of human-technology interfaces to enhance health, comfort, safety, effectiveness and efficiency

3. Integrate
    3.1. Implement and test products and related systems, for predictive, stable, reliable and effective outcomes
    3.2. Implement and test tasks and jobs and related systems, for predictive, stable, reliable and effective outcomes
    3.3. Implement and test organizations and related systems, for predictive, stable, reliable and effective outcomes
    3.4. Implement and test environments and related systems, for predictive, stable, reliable and effective outcomes
    3.5. Implement and test training and education materials to support effective and efficient individual, group, and organizational adoption of design.

Note that it will be impossible to provide the students *all* of the above competencies in just one semester. Nevertheless, the course design should be explicit on which competencies the student will receive training in, and to what extent. This project is also an experiment to test how well the core competencies, as presently articulated, serve educational purposes.

3.6 Lab Exercises

There are 7 lab exercises in the course, each requiring a formal, written, lab report submitted for grading. The labs allow for important *skills training* in three critical areas:

1. **Design of experiments** is a critical research skill. Ability to identify independent and dependent variables relevant to given theories is also critical to deeper understanding of the theories studied. By designing their own experiments, students are forced to think through the given theories and anticipate results predicted by them. Students are also required to analyze their results by relevant descriptive statistics and plots to visualize their data.
2. **Coding** is another critical skill students need to practice. The labs involve several ready-made experimental programs, written in PsychoPy (an open-source package for running experiments in Python), but students are required to change the code according to their desired experimental designs. This will provide them with practice in reading and understanding code and confidence in making changes to code to meet their needs. Students are also required to use R (a free software environment for statistical computing and graphics) to further practice writing code for statistical analysis.
3. **Writing** formal scientific reports is the third critical skill students need to practice. Students are required to report their lab results in a formal lab report prepared according to the American Psychological Association (APA) Publication Manual, 7th ed., using the LaTeX typesetting program. A LaTeX template for the lab reports is provided.

3.7 Lab Programs

Most of the lab exercises in this course have been programmed in Python, specifically, with PsychoPy (https:// www.psychopy.org), an open-source application for running a wide range of psychology experiments. The purpose of this requirement is twofold: (1) The program should allow running of the lab experiments with minimal coding experience (i.e., just following short, step-by-step, instructions) but also (2) allow students in the course to become familiar with programming experiments with Python and modify the experiment by writing some code on their own. The PsychoPy modules are therefore extensively commented and documented so as to serve a stand-alone introduction to Python programming to novices. The specific labs using PsychoPy programs are:

1. **Visual Search Lab**: The participants visually examine a computer display including a number of items as distracters and a target item, which may or may no be present on the display, and indicate with a keystroke whether they found the target item or not. The experimenter prepares several stimulus screens in advance, each containing some combination of the independent variables and with a unique identifier. The experimenter also determines a specific sequence of presentation of the stimulus screens. The independent variables (i.e., variables that the experimenter manipulates) are (1) type of object/character, (2) size of the character, (3) color of the character, (4) number of characters on screen, (5) spacing of the characters on screen, and (6) time the stimulus screen is displayed. The dependent variables (i.e., variables that will be measured in the experiment) are (1) he keystroke in response to presentation of the stimuli: Yes (target present) or No (target not present) and (2) the elapsed time from onset of the stimulus screen to the response, or response time (RT).

2. **Signal Detection Lab**: The program allows students to experiment with the task of detecting a very small signal in a noisy context, and with most of the factors that affect human signal detection performance. The stimuli are visual, presented on a computer display in a tightly controlled manner. The basic image resembles a woven fabric. There are 5 different "fabric" patterns to choose from, differing in the density of the "weave" and corresponding difficulty of the task. The signal is a broken "thread" in the weave pattern. The primary independent variable to be manipulated is the size of the signal. The location of the signal on the screen may be manipulated from completely random to randomly placed in constant areas or varying size. The probability of signal in a given stimulus screen is manipulated by the experimenter from 0% (a signal is never present) to 100% (a signal is present on every screen). The time the stimulus screen is displayed is varied in 3 ways: (1) For a given time, in seconds and 1/100 s (e.g., for 3.75 s), (2) until response, after which the next stimulus screen is presented, and (3) after a separate keystroke. There is a knowledge-of-results (KoR) function (on or off). This function, when selected "on", shall display "correct" or "incorrect" text on the display after a response depending on the response. The number of trials (number of stimulus screens presented) shall be set by the experimenter. The participant responds with a key stroke if they detect a signal in the stimulus screen or not (a Y/N response). The elapsed time from the onset of the stimulus screen to the response key stroke shall be recorded to 1/100 s. The data recorded from the experiment are saved in a comma separated values (csv) file with the columns: (1) Trial number (a running number from the beginning of the experiment); (2) signal's presence (S = signal, N = no signal, or noise); (3) response (Y/N); (4) response time. This is the raw data file. Additionally, a separate data file shall be saved with summary results, in a table with rows for (1) Hit Rate (HR; the number of hits/total number of signals in the experiment), (2) False Alarm Rate (FAR; the number of false alarms/total number of signals in the experiment); (3) Correct Rejection Rate (CRR; the number of correct rejections/total number of noise, i.e., no signal, screens in the experiment); (4) Miss Rate (MR; number of misses/total number of signals in the experiment).

3. **Manual Control Lab**: This is a very elaborate lab program. The software requirements specifications (SRS) for the program are in Appendix E.

4 Redesigned Features of the Course

4.1 General Course Structure

The syllabus for the redesigned course is in Appendix A. The course has a regular weekly schedule, one major topic for each of the 14 weeks of a semester. Each week has roughly the same structure, following a funnel-like progress from very general to very specific. Each week has a very broad, introductory video lecture for a context for the week's topic as well as a handout highlighting the most important aspects of the week's topic. There are somewhat narrower reading assignments. Further narrowing the topic is an online discussion, where students respond to a specific prompt. Finally, a lab exercise allows students to design their own experiment to examine some aspect of the week's topic in great detail.

4.2 Reading Assignments

Reading assignments for each week include a chapter from the course textbook [21], a handout, and an original, seminal, journal article. The handouts provide relatively concise outlines of the most critical elements of the topics covered in the course as well as additional information that cannot be found in the other readings. A sample handout is in Appendix D.

4.3 Online Discussions

Weekly online discussions require students to respond to the prompts provided. The prompts are in Appendix B. Students are also expected to *discuss* the emerging topics and positions with their classmates beyond the given prompt, pressing for deeper thinking with questions or contradictions, and rising to the challenge to answer the questions or defend or correct their position when challenged. Students are also encouraged to use the weekly discussions to ask questions about their assignments (e.g., labs) and collaboratively solve any problems they may encounter.

4.4 Lab Exercises

The 7 lab exercises form the bulk of the work in the course. An example of detailed instructions for a lab are in Appendix C. Many of the labs involve running a simple experiment using software programs provided. Students are expected to design their own experiment by manipulating the independent variable(s) within the experimental program, written in PsychoPy (an open-source package for running experiments in Python), collecting data on their own performance ($N = 1$), analyzing the data using R (a free software environment for statistical computing and graphics), and presenting their results in a formal lab report. The lab assignments, each with a formal, written, lab report, are as follows:

1. **Task analysis**: Student choose a task they are familiar with and perform a task analysis on it using a particular a task analysis method.
2. **Visual search**: Students perform a visual search task under four experimental conditions to test a mathematical model of visual search time. This lab uses a software package developed specifically for this course.
3. **Signal Detection Theory**: The students empirically investigate the impact of various variables on signal detection performance. They calculate the percent of hits, misses, false alarms, and correct rejections, the sensitivity measure *d'* and the bias measure β, as well as plot results in various forms. This lab uses a software package developed specifically for this course.
4. **Information Theory**: The student will empirically investigate the impact of uncertainty on decision time and demonstrate the Hick-Hyman Law. They calculate the H_s values for each experimental condition and plot them against response time, fit a straight line to the data and calculate the straight line equation (linear regression), and evaluate the regression equation and goodness of fit. This lab uses a software package developed specifically for this course.

5. **Manual control**: The students empirically investigate the impact of various variables on their own performance in both discrete and continuous control. In the discrete control part, the students shall compute the Index of Difficulty (ID) for each of the experimental conditions and plot the average movement time (MT) as a function of ID. They shall also calculate the coefficients a and b in Fitts' law and compute the regression equation for all their data points to evaluate Fitts' law. In the continuous control part, the students will examine the effects of gain, time delay, and their interaction by plotting their results for visualization of the data and easy comparison of the effects of the experimental conditions. They will also examine the effects of control order on their performance in a similar manner. This lab uses a software package developed specifically for this course.

6. **Human Reliability Analysis (HRA)**: Students read a story of a medical error and reanalyze the accident using the data from the narrative on a dedicated software. This analysis software is already in existence and is ready for student use. In addition to the accident analysis, students also critically review of the HRA method and the software tool.

7. **Mental Workload**: Students choose a task that they have done before or are familiar enough with to perform the analysis and modify the task in some way to make the task more demanding (e.g., impose time pressure or stricter performance criteria). Students then perform the task, and immediately after the task assess their workload on the six scales of the NASA-TLX and calculate their total workload. This analysis may be done by "paper-and-pencil" and there are software tools available for it online.

4.5 Term Paper

The course project/term paper assignment spans the entire semester and requires students to write a minimum of 2,000-word essay that integrates the various topics and models in Engineering Psychology covered in this course into a coherent view of human (cognitive) capabilities and limitations to be applied to the design of things. In other words, the purpose of the term paper is to allow the students to form a holistic view of both human capabilities and the engineering psychology discipline.

5 Summary

The design of the course maps the course topics to the course calendar (weekly), the BCPE core competencies, and the lab exercises. Multiple objectives (declarative knowledge, writing, critical thinking and creativity, and research methods, data analysis, and modeling) are practiced in each week of the course on each of the course topics. The course topics are also mapped to the the course itself. The final lab assignment asks students to reflect on their own workload in doing the assigned tasks in the course.

References

[1] C. D. Wickens. *Engineering Psychology and Human Performance*. HarperCollins Publishers, 2nd edition, 1992.

[2] F. V. Taylor. Psychology and the design of machines. *American Psychologist*, 12(5):249–258, 1957.

[3] P. M. Fitts. Engineering psychology and equipment design. In S. S. Stevens, editor, *Handbook of Experimental Psychology*, pages 1287–1340. John Wiley & Sons, Inc., New York, 1951.

[4] C. D. Wickens and A Kramer. Engineering psychology. *Annual Review of Psychology*, 36(1):307–348, 1985.

[5] E. C. Poulton. Engineering psychology. *Annual Review of Psychology*, 17(1):177–200, 1966.

[6] D. Gopher and R. Kimchi. Engineering psychology. *Annual Review of Psychology*, 40:431–455, 1989.

[7] B. M. Huey, S. Baron, and D. Ss Kruser. *Quantitative Modeling of Human Performance in Complex, Dynamic Systems*. National Academies Press, 1990.

[8] T. B. Sheridan and W. R. Ferrell. *Man-machine systems; Information, control, and decision models of human performance.* The MIT Press, 1974.

[9] W. B. Rouse. *Systems engineering models of human-machine interaction*. North Holland, New York, 1980.

[10] R. W. Pew and S. Baron. Perspectives on human performance modelling. *Automatica*, 19(6):663–676, 1983.

[11] W.B. Rouse. Models of human problem solving: Detection, diagnosis, and compensation for system failures. *Automatica*, 19(6):613–625, 1983.

[12] E. M. Rantanen and W. F. Moroney. Educational and skill needs of new human factors/ergonomics professionals. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, volume 55, pages 530–534. SAGE Publications, 2011.

[13] E. M. Rantanen and W. F. Moroney. Employers' expectations for education and skills of new human factors/ergonomics professionals. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, volume 56, pages 581–585. SAGE Publications, 2012.

[14] William F Moroney and Esa M Rantanen. Student perceptions of their educational and skill needs in the workplace. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, volume 56, pages 576–580. SAGE Publications, 2012.

[15] E. M. Rantanen, C. Claeys, D. Roder, and W. Moroney. Archival human factors jobs database as a tool for tracking trends in skills and knowledge expectations in the labor market. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, volume 57, pages 457–461. SAGE Publications, 2013.

[16] E. M. Rantanen. Trends in knowledge and skill expectations for new human factors professionals. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, volume 60, pages 370–374. SAGE Publications, 2016.

[17] E. M. Rantanen, D. Boehm-Davis, N. N. Boyle, D. Hannon, and J. D. Lee. Education of future human factors professionals. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, volume 60, pages 418–421. SAGE Publications, 2016.

[18] E. M. Rantanen, S. Rickel, A. Rantanen, and M. Lau. Cross-training in design and human factors. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, volume 62, pages 364–368. SAGE Publications, 2018.

[19] C. J. Thaiss and T. M. Zawacki. *Engaged writers and dynamic disciplines: Research on the academic writing life*. Boynton/Cook, Portsmouth, NH, 2006.

[20] M. Poe, N. Lerner, and J. Craig. *Learning to communicate in science and engineering: Case studies from MIT*. MIT Press, 2010.

[21] C. D. Wickens, J. G. Hollands, R. Parasuraman, and S. Banbury. *Engineering Psychology and Human Performance*. Pearson, 4th edition, 2012.

A Appendix: Syllabus

B Appendix: Online Discussion Prompts

Week 1

Please refer to Ch. 1 in the course text and the handout and the Hendrick article in the Content area. How would you recommend that practitioners and researchers inside the Engineering Psychology discipline (i.e., the engineering psychologists) relate to professionals in myriad other disciplines? Your practical suggestions should reflect your understanding of disciplinary boundaries in general as well as current trends in them. Although you are just beginning this course and cannot be expected to know much about Engineering Psychology, you may use your current level of knowledge as a frame of reference as you think about this assignment.

Week 2

In psychology, and in particular Engineering Psychology, the point of much research is about "getting inside someone's head". In Engineering Psychology people of interest are often expert operators doing very difficult jobs that engineering psychologists try to make easier by design. Often the only way of "getting inside someone's head" is to ask the person what and how they think and how they do their jobs in an interview. While this topic would warrant a semester-long course all on itself, I think that we can at least gain some appreciation of its power and challenges through a weeklong exercise that I also hope will be interesting and fun to you. Hence, please do the following: (1) Read the Hoffman, Crandall, and Shadbolt (1998) article about Critical Decision Method in the Content area. You may also want to watch YouTube videos of your favorite interviewers to learn from their techniques. (2) Think of someone you would like to interview about some critical incident or an important decision in their past. This person could be someone you are presently living with (e.g., a parent), but you can of course conduct the interview by phone of via email, too (email interviews are good as they automatically produce a transcript for later analysis). Press your interviewees until they reveal something you did not know before and provide enough detail for you to understand how and why they behaved the way they did in the situation you discussed. Take good notes! (3) Share your challenges (e.g., what questions to ask, and how) and any particular techniques you find successful in this discussion topic with your classmates.

Week 3

Please think of a personal experience related to visual search (e.g., when driving, or trying to find an item on a mile-long aisle in a grocery store). Discuss why the search task may have been easy, or hard. If easy, what made it easy? If hard, how would you redesign the task and/or the target to make the task easier? Analyze and discuss also you classmates' examples!

Week 4

Please discuss the utility of the Signal Detection Theory (SDT) in engineering psychology in general by coming up with a specific example of a tasks or tasks that could be examined by the SDT. Be very specific about the task (refer to Week 2 topic on task analysis), how you would collect the data on hits and false alarms, and what the d' and β would tell you about the participants' performance. Remember that you should have discussions with each other, so ask questions and offer constructive criticism on your classmates' examples!

Week 5

Show how the Signal Detection Theory (SDT) and Shannon's Theory of Communication, a.k.a. Information Theory, are related. To tackle this question you would need to do much of your own research beyond the assigned readings and think pretty hard about it. This is a very challenging assignment, so please work on it together in this week's discussion!

Week 6

Please think of a personal experience related to attention and tell it in the context of the models you learned about in this week's readings. For example, you might tell about a time when you were successful at multi-tasking, or doing many things at once, or perhaps when you were not, and when your deficit in attentional resources caused you miss something crucial, or some simple errors that could be labeled attentional slips. Whatever you decide to tell about, please be analytical, and show very clearly how the models you learned about this week could explain your story, or how your story might refute a model.

Week 7

Please think of a personal experience with manual control, either a good one, where you were really "in control" and never made any errors, or a bad one, where control was very hard or where you frequently make errors. Analyze your example experience in terms of control theory, and discuss the factors affecting your (good or poor) performance: Index of difficulty (if your example is about discrete control), system stability, feedback, time delays, control order, and gain. If your your example is a "good bad one", offer design suggestions to help with the control.

Week 8

Please read the handout on dual processes and the Rasmussen (1983) paper on the SRK framework. Give an example of some activity you have been engaged in this week and analyze it in terms of this week's theories. What control mode were you in when performing the task or doing the activity (automatic or controlled, system 1 or 2, or skill-, or rule-, or knowledge-based)? Did your behavior/performance match the theoretical characteristics of the control mode you identified? How? Was the control mode appropriate for the activity/task, or would your performance been better had you been in a different control mode? Or did you perhaps shift between control modes?

Week 9

As before, please read the assigned materials (Endsley, 2015, and my handout) first, before contributing to this topic. After you think you have a reasonable understanding about the construct of situation awareness (SA), please describe two (2) cases from your own experience: One should be a good example of a good SA and how it helped you perform well in your example situation, and another a good bad example about a time when your SA was poor and how it hurt your performance or got you in a trouble in some way. Please be very analytical in your description of these cases and list all the factors that you think either helped you to gain and maintain a good SA or prevented you from having sufficient SA for your task.

Week 10

For this week's discussion, please offer personal examples about decisions you have made. These may be big (such as what college to attend, or what car to buy), or small (what to eat for dinner, or what to wear on any given day), or split-second decisions (maneuvering your car to avoid a fender-bender or how to score in some game), or anything in between or outside these examples. The key to this discussion is to provide much detail about both the circumstances and your own state at the time the decision was made (e.g., under time- or other pressure, being tired or unprepared, &c.) and analyze your example by the Kahneman and Klein (2009) article and my handout. Please offer your help in analysis of your classmates' examples, too!

Week 11

Please describe errors you have made recently, so that all the details are still fresh in your memory. The errors can range from very simple such as forgetting to attend a telecon to more serious ones, perhaps made in a homework assignment or spending good money on a bad purchase. Please analyze your error as deeply as you can (to find a root cause for it). Given the context of your error, how would you go about quantifying your reliability in relevant tasks?

Week 12

Please use my handout, the seminal Weick (1987) paper, and the FRAM website for references, and discuss how you might apply the Safety II thinking in your own everyday "operations" in your everyday lives. If you think presently along the lines of Safety I, describe that, too, but then speculate how you might move to the Safety II direction. This is pretty headache-inducing stuff, so I expect to see many questions and a lively discussion on the topic and your examples!

Week 13

"Multitasking makes you stupid" was the title of the original article in *The Wall Street Journal* on February 27, 2003, and it has been repeated innumerable times since then. What is your experience with multitasking? Make sure you differentiate between multitasking and time-sharing, and identify the factors that make each successful, or not. Please offer your help in analysis of your classmates' examples, too!

Week 14

For this week's discussion, please reflect on the tasks you have been required to perform in this course and answer the following questions: (1) What were the primary drivers of workload in this course? (2) what strategies did you employ to manage your workload and avoid overload situations? and (3) what impact did your workload in this course have in your performance in it?

C Appendix: Sample Lab and Term Paper Instructions

D Appendix: Sample Handout

E Appendix: Sample Software Requirements Specifications for the Manual Control Lab