Awardee of The Office of the National Coordinator for Health Information Technology

Component 15: Usability and Human Factors

Instructor Manual

Version 3.0/Spring 2012

Notes to Instructors

This Instructor Manual is a resource for instructors using this component. Each component is broken down into units, which include the following elements:

- Learning objectives
- Suggested student readings, texts, reference links to supplement the narrated PowerPoint slides
- Lectures (voiceover PowerPoint in Flash format); PowerPoint slides (Microsoft PowerPoint format), lecture transcripts (Microsoft Word format); and audio files (MP3 format) for each lecture
- Self-assessment questions reflecting Unit Objectives with answer keys and/or expected outcomes
- Application Activities (e.g., discussion questions, assignments, projects) with instructor guidelines, answer keys and/or expected outcomes

This material was developed by Columbia University, funded by the Department of Health and Human Services, Office of the National Coordinator for Health Information Technology under Award Number 1U24OC000003.

Contents

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Likewise, the above also applies to the Curriculum Development Centers (including Columbia University, Duke University, Johns Hopkins University, Oregon Health & Science University, University of Alabama at Birmingham, and their affiliated entities).

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Component Overview

This component will discussion of rapid prototyping, user-centered design understanding effects of new technology workflow on downstream processes; facilitation of unit-wide focus groups or simulation.

Component Objectives

At the completion of this component, students will be able to:

- Articulate a systems approach to usability and human factors as it applies to health information technology.
- Explain the cognitive consequences of health information technology on clinical performance.
- Identify the consequences of suboptimal design in the delivery of healthcare.
- Apply methods of cognitive research, sources of usability evidence, and principles of user-centered design to decisions regarding systems evaluation, technology evaluation, and iterative design, given a population of users.
- Apply requirements engineering methods to inform design and technology selection.
- Demonstrate concept knowledge of cognition and human performance models in their relevance to systems evaluation methods.
- Apply concept knowledge of cognitive, physical and organization ergonomics to human factors engineering.
- Select the most appropriate usability evaluation method, given particular system, setting, and development phase.
- Apply principles of usability and design to critiquing EHR systems and to making recommendations for iterative improvement.
- Diagnose problems associated with a clinical decision support system.
- Apply cognitive methods of analysis to medical device testing.
- Evaluate user interface designs using cognitive methods of analysis, usability testing, and Nielsen's heuristic evaluation method.
- Diagnose various types of error and create or select potential solutions.
- Select appropriate technology input methods given different technology uses, user populations and contexts.
- Describe how information visualization can support and enhance the representation of trends and aggregate data.
- Describe the role of mobile and ubiquitous computing in healthcare.

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Component Authors

Assigned Institution

Columbia University, New York, NY

Team Lead

Dave Kaufman, PhD

Associate Research Scientist in the Department of Biomedical Informatics at Columbia University Medical Center.
Dr. Kaufman has extensive experience in 1) human computer interaction in the context of health information technologies, especially as it relates to the elderly, digital divide and low literacy populations, 2) information seeking behavior and decision making in healthcare contexts and 3) conceptual understanding of biomedical information and decision making by lay people. He has published several papers related to applying video-analytic cognitive science methods to the study of the productive use of technology by clinicians and patients. Trained as an educational psychologist and cognitive scientist, he has conducted several usability evaluation and training studies in relation to a large-scale telemedicine initiative for older adults with diabetes.

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Component 15/Unit 1

Unit Title
People and Technology, Studies of Technology

Unit Description
This unit will apply methods of cognitive research, sources of usability evidence, and principles of user-centered design to decisions regarding systems evaluation, technology evaluation, and iterative design, given a population of users.

Unit Objectives
By the end of this unit, the student will be able to:

1. Explain the importance of technology in health.
2. Describe the contributions of Human-Computer interaction to the Health field
3. Describe the seven stages of User Activity in Norman's Theory of Action
4. Demonstrate concept knowledge of principles of user-centered design, methods of cognitive research, and sources of usability evidence.
5. Apply the principles of user-centered design to address the challenges to effective design
6. Compare and contrast usability evaluation methods.
7. Identify and differentiate various types of errors in medicine
8. Identify patient safety issues in the workplace and at home

Unit Topics / Lecture Titles
A. People and Technology, Studies of Technology
B. Usability and Human Factors Introduction
C. Good Design and Poor Design
D. Introduction to the studies of technology and Human-Computer Interaction
E. Norman's Theory of Action and Design of Everyday Things
F. Introduction to user-centered design

Unit References
(All links accessible as of 1/1/2014)

*Indicates this link is no longer functional.

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Books & Journals

1. Horsky, J., Kaufman, D.R., Oppenheim, M.I. & Patel, V.L. (2003). A framework for
2. analyzing the cognitive complexity of computer-assisted clinical ordering. Journal of Biomedical Informatics, 36, 4-22.
3. Kaufman, D. R., Pevzner, J., Rodriguez, M., Cimino, J. J., Ebner, S., Fields, L., et al.
4. (2009). Understanding workflow in telehealth video visits: Observations from the IDEATel project. Journal of Biomedical Informatics, 42(4), 581-592.
5. Kaufman, D.R. & Starren, J. B. (2006). A methodological framework for evaluating
6. mobile health devices. In the Proceedings of the American Medical Informatics Annual Fall Symposium. Philadelphia: Hanley & Belfus, P.978.
7. Kaufman, D.R., Patel, V.L., Hilliman, C., Morin, P.C., Pevzner, J, Weinstock, Goland, R.
8. Shea, S. & Starren, J. (2003). Usability in the real world: Assessing medical information technologies in patients' homes. Journal of Biomedical Informatics, 36, 45-60.
9. Nielsen, J. (1993). Usability engineering. Boston: Academic Press.
10. Norman, D. A. (1986). Cognitive engineering. In D. A. Norman & S. W. Draper (Eds.),
11. User centered system design: New perspectives on human-computer interaction (pp. 31-61). Hillsdale, NJ: Lawrence Erlbaum Associates.

Lecture a Images

Slide 4: *All of these images were drawn from research in which Dr. Kaufman was an investigator. In the bottom left hand corner, the glucose meter is from an unpublished study investigating the usability of the device. The infusion pump is from research conducted by Dr. Vimla Patel and Dr. Kaufman (unpublished). The telemedicine unit is a picture of the device used in the IDEATEL study in which Dr. Kaufman was a part of for 6 years. The nurse case manager scrutinizing 2 screens was draw from the IDEATEL work conducted by Dr. Kaufman and colleagues. Below the nurse and towards the middle is a picture of a computer-provider order entry screen. This work was a collaborative study with Jan Horsky and Vimla Patel. The image in the bottom left is a picture of an eClinicalWorks screen. This was part of a usability study conducted by Dr. Kaufman in*

*Indicates this link is no longer functional.

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collaboration with the New York City Department of Health and Mental Hygiene.

Images of Electronic Health Record Systems: Clockwise from the bottom left-hand corner

- Kaufman, D.R. & Starren, J. B. (2006). A methodological framework for evaluating
- mobile health devices. In the Proceedings of the American Medical Informatics Annual Fall Symposium. Philadelphia: Hanley & Belfus. 978
- Kaufman, D.R., Pevzner, J, Hilliman, C., Weinstock, R.S., Teresi, J. Shea, S. & Starren,
- J. (2006). Re-designing a telehealth diabetes management program for a digital divide seniors population. Home, Healthcare, Management & Practice. 18: 223-234 Infusion Pump—unpublished work (2002) with Patel, Kubose and Kaufman
- Kaufman, D. R., Pevzner, J., Rodriguez, M., Cimino, J. J., Ebner, S., Fields, L., et al.
- (2009). Understanding workflow in telehealth video visits: Observations from the IDEATel project. Journal of Biomedical Informatics, 42(4), 581-592.
- Horsky, J., Kaufman, D.R., Oppenheim, M.I. & Patel, V.L. (2003). A framework for
- analyzing the cognitive complexity of computer-assisted clinical ordering. Journal of Biomedical Informatics, 36, 4-22.
- Kaufman, D.R., Patel, V.L., Hilliman, C., Morin, P.C., Pevzner, J, Weinstock, Goland, R.
- Shea, S. & Starren, J. (2003). Usability in the real world: Assessing medical information technologies in patients' homes. Journal of Biomedical Informatics, 36, 45-60.
- eClinicalWorks screen. Unpublished usability analysis of eClinicalWorks (2008) with
- Kaufman & Hripcsak Leape, L. L., Error in Medicine. (1994). JAMA, 272:1851-1857.
- New perspectives on human-computer interaction (pp. 31-61). Hillsdale, NJ: Lawrence
- Erlbaum Associates. U.S. Department of Commerce. (2002). A nation online: How Americans are expanding their use of the Internet. Washington, DC: U.S. Government Printing Office.

Slide 5: Image: a cartoon of a man smashing his computer with an ax. This is clipart image capturing the frustration of computer user.

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Slide 7: Photo credits:

- Image 1: Very old telephone: Retrieved on June 15, 2010 from http://www.flickr.com/photos/adulau/2044441912/
- Image 2: Old poster advertisement for an Electro Lux vacuum with a woman using it: Retrieved on June 15, 2010 from http://www.flickr.com/photos/derpunk/2374293386/

Slide 8: Images: various new technologies such as a Blackberry, GPS, iPhone, iPad and iPods. Retrieved on June 15, 2010.

- http://www.flickr.com/photos/myuibe/4309248483/sizes/o/#cc_license
- http://www.flickr.com/photos/cdharrison/338087486/sizes/l/#cc_license
- http://www.flickr.com/photos/liewcf/4285189817/sizes/l/
- http://www.flickr.com/photos/stigster/3761714132/sizes/l/
- http://www.flickr.com/photos/williamhook/2830319467/sizes/l/#cc_license

Slide 9: Retrieved on June 15, 2010. Various images of early medical technologies:

- Ancient Doctor's Tools: http://www.flickr.com/photos/curiousexpeditions/2197609542/
- Ancient Egyptian stethoscope carved in stone: http://www.flickr.com/photos/emmalouise99/1635483608/
- Ancient Enemas: http://www.flickr.com/photos/curiousexpeditions/2196820973/in/set-72157603726203746/
- Mechanical Therapy (hand drawn picture of a man sitting on a complex machine): http://www.flickr.com/photos/curiousexpeditions/2196822679/

Lecture b Graph

Slide4: Kohn, L. T., Corrigan, J., & Donaldson, M. S. (2000). To err is human: building a safer health system: National Academy Press.

Lecture b Images

Slide 6: Retrieved on June 15, 2010. Photo: Infusion Pump: http://www.flickr.com/photos/timgee/2554587443/sizes/l/

Slide 7: Kaufman, D.R. & Starren, J. B. (2006). A methodological framework for evaluating mobile health devices. In the Proceedings of the American Medical Informatics Annual Fall Symposium. Philadelphia: Hanley & Belfus, P.978.

*Indicates this link is no longer functional.

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Slide 9: Kaufman, D.R. & Rockoff, M.L. (2006). Promoting online health information-seeking in seniors: a community-based organizations approach. Generations 30(2): 55-57.
Slide 10: Kaufman, D.R. & Rockoff, M.L. (2006). Promoting online health information-seeking in seniors: a community-based organizations approach. Generations 30(2): 55-57.
Slide 11: Kaufman, D.R., Pevzner, J, Hilliman, C., Weinstock, R.S., Teresi, J. Shea, S. & Starren, J. (2006). Re-designing a telehealth diabetes management program for a digital divide seniors population. Home, Healthcare, Management & Practice. 18: 223-234.
Slide 12: Kaufman, D.R., Pevzner, J, Hilliman, C., Weinstock, R.S., Teresi, J. Shea, S. & Starren, J. (2006). Re-designing a telehealth diabetes management program for a digital divide seniors population. Home, Healthcare, Management & Practice. 18: 223-234.
Slide 15: Ruland, C. M., Starren, J., & Vatne, T. M. (2008). Participatory design with children in the development of a support system for patient-centered care in pediatric oncology. J Biomed Inform, 41(4), 624-635. doi: S1532-0464(07)00111-6 [pii] 10.1016/j.jbi.2007.10.004.
Slide 16: Norman, D. A. (1986). Cognitive engineering. In D. A. Norman & S. W. Draper (Eds.), User centered system design: New perspectives on human-computer interaction (pp. 31-61). Hillsdale, NJ: Lawrence Erlbaum Associates.

Lecture c Images
Slide 3: Retrieved on January 6th, 2011 from http://www.flickr.com/photos/cyberslayer/1437957836/sizes/l/in/photostream/
Slide 4: Horsky, J., Kaufman, D.R., Oppenheim, M.I. & Patel, V.L. (2003). A framework for analyzing the cognitive complexity of computer-assisted clinical ordering. Journal of Biomedical Informatics, 36, 4-22.
Slide 5: Retrieved on June 15th, 2010 from

- http://www.nlm.nih.gov/medlineplus/seniorshealth.html
- http://upload.wikimedia.org/wikipedia/commons/6/66/Butterfly_large.jpg

Slide 7: Lin, L., Isla, R., Doniz, K., Harkness, H., Vicente, K. J., & Doyle, D. J. (1998). Applying human factors to the design of medical equipment: patient-controlled analgesia. Journal of Clinical Monitoring & Computing, 14(4), 253-263.
Slide 8: Kaufman, D.R. & Starren, J. B. (2006). A methodological framework for evaluating mobile health devices. In the Proceedings of

*Indicates this link is no longer functional.

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the American Medical Informatics Annual Fall Symposium. Philadelphia: Hanley & Belfus. 978

Suggested Readings

1. Carayon P. Human factors and ergonomics in health care and patient safety. (2007).
2. In: Carayon P, Handbook of human factors and ergonomics in health care and patient safety. Mahwah, NJ: Erlbaum, 3–20.
3. Kohn LT, Corrigan JM, Donaldson MS, eds. (1999).To Err is Human. Washington DC: National Academy Press, 1999.
4. Leape, L. L., (1994). Error in Medicine. JAMA, 272:1851-1857.
5. Lin L, Isla R, Harkness H, Doniz K, Vicente KJ & Doyle DJ (1998). Applying human factors to the design of medical equipment: patient-controlled analgesia. Journal of Clinical Monitoring & Computing 14: 253-263.
6. Nielsen, Jakob, Heuristic Evaluation. http://www.useit.com/papers/heuristic/heuristic_list.html
7. Nielsen, Jakob, http://www.useit.com/
8. Norman, D. A. (1990). The Design of Everyday Things. Doubleday: New York, New York.
9. Patel, V.L., Kaufman, D.R. (2006) Cognitive Science and Biomedical Informatics. In E.H. Shortliffe & J.J. Cimino (Eds.) Biomedical Informatics: Computer Applications in Health Care and Biomedicine. New York: Springer-Verlag. (pp. 133-185).
10. Preece, J. Rogers, Y. & Sharp, H. (2007) Interaction Design: Beyond Human-Computer Interaction. 2nd Edition. New York, NY: John Wiley & Sons.
11. Ruland C.M., Starren J., Vatne T.M. (2008). Participatory design with children in the development of a support system for patient-centered care in pediatric oncology. Journal of Biomedical Informatics, 41 (4), 624-35

Student Application Activities

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comp15_unit1_self-assess_key.doc

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Component 15/Unit 2

Unit Title
Requirements Engineering

Unit Description
This unit will discuss applying requirements engineering methods to inform design and technology selection.

Unit Objectives
By the end of this unit the student will be able to:

1. Explain the role of requirements gathering in usability evaluation.
2. Identify the uses, advantages, and disadvantages of data collection
1. Methods used for requirements gathering
2. Identify contextual design principles as they apply to the healthcare setting
3. Describe the methods to interpret results of data collection

Unit Topics / Lecture Titles
1. Requirements & Engineering
2. Introduction to Requirements
3. Healthcare Workflow
4. Analysis of workflow
5. Contextual Inquiry
6. Requirements Engineering

Unit References
(All links accessible as of 1/1/2014)

Journals & Books
1. Holtzblatt, K., & Jones, S. (1993). Contextual inquiry: A participatory technique for system design. In D. Schuler, & A. Namioka (Eds.), Participatory Design: Perspectives on Systems Design (pp. 177-210). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Websites
1. Retrieved on June 21, 2010 from http://en.wikipedia.org/wiki/Requirement

*Indicates this link is no longer functional.

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2. Retrieved on June 21. 2010 from http://en.wikipedia.org/wiki/Contextual_inquiry

Table

Slide 13: Preece, J. Rogers, Y. & Sharp, H. (2007) Interaction Design: Beyond Human-Computer Interaction. 2nd Edition. New York, NY: John Wiley & Sons

Images

Slide 15: Image taken from video from Dave Kaufman's research. This is a picture of a nurse case manager interviewing a patient using an interactive telemedicine system.

- Kaufman, D. R., Pevzner, J., Rodriguez, M., Cimino, J. J., Ebner, S., Fields, L., et al. (2009). Understanding workflow in telehealth video visits: Observations from the IDEATel project. Journal of Biomedical Informatics, 42(4), 581-592.

Slide 17:

This illustrates workflow with a nurse case manager communicating with various clinical personnel and the patient through a variety of modalities including telephone, email and face to face.

- Kaufman, D. R., Pevzner, J., Rodriguez, M., Cimino, J. J., Ebner, S., Fields, L., et al. (2009). Understanding workflow in telehealth video visits: Observations from the IDEATel project. Journal of Biomedical Informatics, 42(4), 581-592.

Suggested Readings

1. http://en.wikipedia.org/wiki/Requirement
2. http://en.wikipedia.org/wiki/Contextual_inquiry
3. Beyer, H. & Holtzblatt, K. (1998) Contextual Design: Defining Customer-Centered
4. Systems. San Francisco: Morgan Kaufmann Publishers.
5. Kaufman, D. R., Pevzner, J., Rodriguez, M., Cimino, J. J., Ebner, S., Fields, L., et al. (2009). Understanding workflow in telehealth video visits: Observations from the IDEATel project. Journal of Biomedical Informatics, 42(4), 581-592.
6. Preece, J. Rogers, Y. & Sharp, H. (2007) Interaction Design: Beyond Human-Computer Interaction. 2nd Edition. New York, NY: John Wiley & Sons.

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Student Application Activities
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Component 15/Unit 3

Unit Title
Cognition and Human Performance

Unit Description
Demonstrate concept knowledge of cognition and human performance models in their relevance to systems evaluation methods.

Unit Objectives
By the end of this unit the student will be able to:

1. Define the concept of cognitive engineering
2. Describe the representational effect as it applies to human computer interaction and web design
3. Describe how humans process information and obtain skills
4. Describe the Gestalt principles of perception and their relevance to human computer interaction and cognitive theory
5. Describe the processes of memory and their relationship to web-design
6. Describe the cognitive constructs for mental representation
7. Explain how cognition and human performance models should inform iterative design processes

Unit Topics / Lecture Titles
A. A model of human information processing
B. Basics of human cognition
C. Attention, perception and memory
D. Mental models and schemata
E. Representational effects
F. Distributed cognition
G. Skill acquisition
H. Implications for iterative design

Unit References
(All links accessible as of 1/1/2014)

Journals & Books
1. Ancker JS, Chan C, Kukafka R. Interactive graphics to demonstrate health risks: formative development and qualitative evaluation. Journal of Health Communication2009; 14: 461-475.

*Indicates this link is no longer functional.

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2. Goldstein, E. Bruce (2009). “Perceiving Objects and Scenes § The Gestalt Approach to Object Perception”. Sensation and perception (8th ed.). Cengage Learning. ISBN 9780495601494.
3. Horsky, J., Kaufman, D.R., Oppenheim, M.I. & Patel, V.L. (2003). A framework for analyzing the cognitive complexity of computer-assisted clinical ordering. Journal of Biomedical Informatics, 36, 4-22.
4. Kaufman, D.R., Patel, V.L., Hilliman, C., Morin, P.C., Pevzner, J, Weinstock, Goland, R. Shea, S. & Starren, J. (2003). Usability in the real world: Assessing medical information technologies in patients’ homes. Journal of Biomedical Informatics, 36, 45-60.
5. Preece, J. Rogers, Y. & Sharp, H. (2007) Interaction Design: Beyond Human-Computer Interaction. 2nd Edition. New York, NY: John Wiley & Sons. P. 92
6. Stillings, N. A., Weisler, S. E., Chase, C. H., Feinstein, M. H., Garfield, J. L., & Rissland, E. L. (1995). Cognitive science: An introduction (2nd ed.). Cambridge, MA: MIT Press.
7. Preece, J. Rogers, Y. & Sharp, H. (2007) Interaction Design: Beyond Human-Computer Interaction. 2nd Edition. New York, NY: John Wiley & Sons.

Lecture a Images:

Slide 6:

- Image Keyboard- Retrieved on August 10th, 2010 from http://www.flickr.com/photos/yvettemn/139890573/sizes/z/in/photostream/
- Image Steering Wheel- Retrieved on August 10th, 2010 from http://www.flickr.com/photos/jessicafm/82279328/sizes/m/in/photostream/

Slide 8: Image of Human Information Processing from:
Kaufman, D. (2010). Model of human information processing. Department of Biomedical Informatics, Columbia University Medical Center.
Slide 11-16: Kaufman, D. (2010). Images of proximity. Department of Biomedical Informatics, Columbia University Medical Center.
Slide 18-20: Kaufman, D. (2010). Images of flight status. Department of Biomedical Informatics, Columbia University Medical Center.
Slide 23: Kaufman, D. (2010). Personal image of bird watching. Department of Biomedical Informatics, Columbia University Medical Center.
Slide 24: Horsky, J., Kaufman, D.R., Oppenheim, M.I. & Patel, V.L. (2003). A framework for analyzing the cognitive complexity of computer-assisted clinical ordering. *Journal of Biomedical Informatics*, 36, 4-22.

*Indicates this link is no longer functional.

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Slide 26: Images of Alarm clocks: Retrieved August 5th, 2010, from

- http://farm4.static.flickr.com/3275/3041923556_187f3e3351.jpg
- http://www.flickr.com/photos/stuartpilbrow/4236152267/

Slide 27: Kaufman, D.R., Patel, V.L., Hilliman, C., Morin, P.C., Pevzner, J, Weinstock, Goland, R. Shea, S. & Starren, J. (2003). Usability in the real world: Assessing medical information technologies in patients' homes. *Journal of Biomedical Informatics*, 36, 45-60.

Slide 28: Ancker JS, Chan C, Kukafka R. Interactive graphics to demonstrate health risks: formative development and qualitative evaluation. Journal of Health Communication* 2009; 14: 461-475.

Lecture b Images

Slide 12: Kaufman, D. (2010). Personal image of bird schema. Department of Biomedical Informatics, Columbia University Medical Center.

Lecture c Images

Slide 6: Kaufman, D. (2010). Personal photo of ATM machine. Department of Biomedical Informatics, Columbia University Medical Center.

Slide 9, 10 & 13: Images from Microsoft Clipart, retrieved August 5th, 2010 from Microsoft, word.

Slide 14: Kaufman, D. R., Pevzner, J., Rodriguez, M., Cimino, J. J., Ebner, S., Fields, L., et al. (2009). Understanding workflow in telehealth video visits: Observations from the IDEATel project. Journal of Biomedical Informatics, 42(4), 581-592.

Suggested Readings

1. Ancker JS, Senathirajah Y, Kukafka R, Starren JB. Design features of graphs for communicating health risks: A systematic review. Journal of the American Medical Informatics Association 2006; 13(6): 608-618
2. Ancker JS, Kukafka R. A combined qualitative method for testing an interactive risk communication tool. Proceedings/AMIA Annual Fall Symposium 2007: 16-20.
3. Patel, V.L., Kaufman, D.R. (2006) Cognitive Science and Biomedical Informatics. In E.H. Shortliffe & J.J. Cimino (Eds.) Biomedical Informatics: Computer Applications in Health Care and Biomedicine. New York: Springer-Verlag. (pp. 133-185).
4. Preece, J. Rogers, Y. & Sharp, H. (2007) Interaction Design: Beyond Human-Computer Interaction. 2nd Edition. New York, NY: John Wiley & Sons

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Student Application Activities
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Component 15/Unit 4

Unit Title
Human Factors and Healthcare

Unit Description
Apply concept knowledge of human factors to the evaluation of systems-design and the study of human errors and patient safety.

Unit Objectives
By the end of this unit the student will be able to:

1. Distinguish between human factors and human computer interactions (HCI) as they apply to usability
2. Explain how cognitive, physical and organization ergonomics can be applied to human factors engineering
3. Describe how the concepts of mental workload, selective attention and information overload affect usability
4. Describe the different dimensions of the concept of human error
5. Describe a systems-centered approach to error and patient safety
6. Apply methods for measuring mental workload and information overload
7. Describe how human factors analysis can be applied to the study of medical devices

Unit Topics / Lecture Titles
A. Introduction to human factors engineering
B. Cognitive, physical and organization ergonomics
C. Mental workload
D. Selective attention and information overload
E. The nature of human error and patient safety
F. Implications of human factors for medical devices

Unit References
(All links accessible as of 1/1/2014)

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Lecture a Images

Slide 3:

- 1.1: Infusion Pump—unpublished work (2002) with Patel, Kubose and Kaufman
- 1.2: Kaufman, D.R. & Starren, J. B. (2006). A methodological framework for evaluating mobile health devices. In the Proceedings of the American Medical Informatics Annual Fall Symposium. Philadelphia: Hanley & Belfus. 978
- 1.3: Kaufman, D.R., Pevzner, J, Hilliman, C., Weinstock, R.S., Teresi, J. Shea, S. & Starren, J. (2006). Re-designing a telehealth diabetes management program for a digital divide seniors population. Home, Healthcare, Management & Practice. 18: 223-234
- 1.4: Kaufman, D. R., Pevzner, J., Rodriguez, M., Cimino, J. J., Ebner, S., Fields, L., et al. (2009). Understanding workflow in telehealth video visits: Observations from the IDEATel project. Journal of Biomedical Informatics, 42(4), 581-592.
- 1.4: Horsky, J., Kaufman, D.R., Oppenheim, M.I. & Patel, V.L. (2003). A framework for analyzing the cognitive complexity of computer-assisted clinical ordering. Journal of Biomedical Informatics, 36, 4-22.
- 1.5: Kaufman, D.R., Patel, V.L., Hilliman, C., Morin, P.C., Pevzner, J, Weinstock, Goland, R. Shea, S. & Starren, J. (2003). Usability in the real world: Assessing medical information technologies in patients' homes. Journal of Biomedical Informatics, 36, 45-60.
- 1.6: eClinicalWorks screen. Unpublished usability analysis of eClinicalWorks (2008) with Kaufman & Hripcsak

Slide 10: Images of Nuclear Power Plant Control Room: Retrieved August 5th, 2010, from By Yovko Lambrev, http://simplevisions.org/index.php?showimage=51 [CC-BY-3.0 (www.creativecommons.org/licenses/by/3.0)], via Wikimedia Commons

Slide 11: Images of Airplane Cockpit: Retrieved August 5th, 2010 from http://www.flickr.com/photos/mugland/35440009

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Lecture b Images

Slide 3: Image of patient safety, Retrieved on August 5th, 2010 from http://www.flickr.com/photos/andyde/4762081047/sizes/l/#cc_license
Slide 9: Image of space shuttle challenger disaster, Retrieved on August 5th, 2010 from http://grin.hq.nasa.gov/ABSTRACTS/GPN-2004-00012.html
Slide 10: Image of deep water horizon explosion, Retrieved on August 5th, 2010 from http://www.flickr.com/photos/skytruth/4733160839/sizes/l/
Slide 11: Reason J (2000). Human error: models and management. *BMJ*, 320:768-70
Slide 12 & 13: Images drawn by David Kaufman, Department of Biomedical Informatics, Columbia University Medical Center.
Slide 19: Henriksen, K., Dayton, E., Keyes, M. A., Carayon, P., & Hughes, R. (2008). Understanding Adverse Events: A Human Factors Framework. In H. R.G. (Ed.), Patient Safety and Quality: An Evidence-Based Handbook for Nurses (pp. 84-101). Rockville, MD: Agency for Healthcare Research and Quality.
Slide 21: Zhang, J., Patel, V. L., Johnson, T. R., & Shortliffe, E. H. (2004). A cognitive taxonomy of medical errors. J Biomed Inform, 37(3), 193-204. doi: 10.1016/j.jbi.2004.04.004

Lecture c Images

Slide 12: Lin, L., Isla, R., Doniz, K., Harkness, H., Vicente, K. J., & Doyle, D. J. (1998). Applying human factors to the design of medical equipment: patient-controlled analgesia. Journal of Clinical Monitoring & Computing, 14(4), 253-263.
Slide 15: Kaufman, D.R. & Starren, J. B. (2006). A methodological framework for evaluating mobile health devices. In the Proceedings of the American Medical Informatics Annual Fall Symposium. Philadelphia: Hanley & Belfus. 978

Suggested Readings

1. Carayon P. (2007) Handbook of Human Factors and Ergonomics in Health Care and Patient Safety. Mahwah, NJ: Lawrence Erlbaum Associates.
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Student Application Activities

comp15_unit4_discuss.doc
comp15_unit4_discuss_key.doc
comp15_unit4_self-assess.doc
comp15_unit4_self-assess_key.doc

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Component 15/Unit 5

Unit Title
Usability evaluation methods

Unit Description
Select the most appropriate usability evaluation method, given particular system, setting, and development phase.

Unit Objectives
By the end of this unit the student will be able to:

1. Describe the importance of usability in relation to health information technologies
2. List and describe usability evaluation methods
3. Given a situation and set of goals, determine which usability evaluation method would be most appropriate and effective
4. Describe the appropriate tasks for a usability test
5. Describe the usability testing environment, required equipment, logistics, and materials
6. Conduct a cognitive walkthrough

Unit Topics / Lecture Titles
A. Why usability matters
B. Interviews
C. Focus groups
D. Questionnaires
E. Cognitive task analysis
F. Usability inspection methods
G. Cognitive walkthrough
H. Heuristic evaluation
I. Usability testing
J. Video-analysis

Unit References
(All links accessible as of 1/1/2014)

Journals/Books
1. Kaplan B & Harris-Salamone K. Health IT Success and Failure: Recommendations from Literature and an AMIA Workshop. J Am Med Inform Assoc. 2009; 16:291-299.

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Lecture a Images

Slide 7: Kaufman, D.R., Patel, V.L., Hilliman, C., Morin, P.C., Pevzner, J, Weinstock, Goland, R. Shea, S. & Starren, J. (2003). Usability in the real world: Assessing medical information technologies in patients' homes. Journal of Biomedical Informatics, 36, 45-60.
Slide 15-16: Likert Scale samples created by Kaufman, D. (2010). Department of Biomedical Informatics, Columbia University Medical Center.

Lecture b Images

Slide 21: Clipart image created by David Kaufman, on August 5th, 2010.
Slide 23: Khan SA, Ancker JS, Li J, Kaufman D, Hutchinson C, Cohall A, Kukafka R. GetHealthyHarlem.org: developing a web platform for health promotion and wellness driven by and for the Harlem community. AMIA Annu Symp Proc. 2009;2009:317–21.

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Suggested Readings

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Student Application Activities

comp15_unit5_discuss.doc
comp15_unit5_discuss_key.doc
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comp15_unit5_self-assess_key.doc

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Component 15/Unit 6

Unit Title
Electronic Health Records and Usability

Unit Description
Apply principles of usability and design to critiquing EHR systems and to making recommendations for iterative improvement.

Unit Objectives
By the end of this unit the student will be able to:

1. Discuss the role of usability testing, training and implementation of electronic health records
2. Describe and define usability as it pertains to the EHR (HIMSS document)
3. Explain the challenges of EHR design and usability in typical workflow
4. Identify a set of well-established principles of usability and design and describe their application to EHRs (HIMSS document)
5. Identify and explain usability methods for enhancing efficiency of use and minimizing likelihood of user error (HIMSS document)
6. Explain how user-centered design can enhance adoption of EHRs
7. Describe Web 2.0 and novel concepts in system design
8. Identify potential methods of assessing and rating EHR usability when selecting an appropriate EHR system (HIMSS document)

Unit Topics / Lecture Titles
A. Electronic health records in medicine
B. Usability, training and implementation
C. Special case of computerized physician order entry
D. Effects of and effects with technology
E. Evaluating EHRs
F. Usability inspection
G. Heuristic evaluation
H. Usability testing

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I. Focus groups
J. EHRs and user-centered design
K. Web 2.0 and novel concepts in system design

Unit References
(All links accessible as of 1/1/2014)

Journals/Books

1. McDonnell C, Werner K, Wendel L. Electronic Health Record Usability: Vendor Practices and Perspectives. AHRQ Publication No. 09(10)-0091-3-EF. Rockville, MD: Agency for Healthcare Research and Quality. May 2010. (Slides 7 & 10)
1. Silverstein, S. (2009). Are Health IT Designers, Testers and Purchasers Trying to Harm Patients? Part 2 of a Series Healthcare Renewal Blog, Sunday, February 22, 2009. Retrieved on August 11th, 2010 from http://hcrenewal.blogspot.com/2009/02/are-health-it-designers-testers-and.html (Slides 11-14)
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7. Senathirajah Y, Bakken, S., editor. A User-Configurable EHR using Web 2.0 Approaches. AMIA Spring 2008; 2008; Phoenix, AZ: AMIA. (Slide 21).
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13. Karsh, B-TB. (2010). Health IT Design and Usability: Myths and Realities. AHRQ/NIST EHR Usability Conference; 2010; Washington DC.
14. Friedman, C. (2010). Usability in Health IT: technical strategy, research, and implementation: summary workshop. National Institute of Standards and Technology, U.S., Department of Commerce. Retrieved on September 4th, 2012 from http://www.nist.gov/itl/hit/upload/U-HIT_Workshop_Report_Publication_Version.pdf (slide13)
15. Koppel , R., Metlay, J.P., Cohen, A., Abaluck, B., et al. (2005). Role of computerized physician order entry systems in facilitating medical errors. JAMA 293(10): 1197-1203. (slide23)
16. Khajouei, R., Jaspers, MWM. CPOE System Design Aspects and Their Qualitative Effect on Usability. eHealth Beyond the Horizon – Get IT There. S.K. Andersen et al. (Eds). IOS Press, 2008. 309-314. (slides 27 & 28)

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Lecture a Images

Slides 12-15: Silverstein, S. (2009). Are Health IT Designers, Testers and Purchasers Trying to Harm Patients? Part 2 of a Series Healthcare Renewal Blog, Sunday, February 22, 2009. Retrieved on August 11th, 2010 from http://hcrenewal.blogspot.com/2009/02/are-health-it-designers-testers-and.html

Slides 17-19: Silverstein, S. (2009). Are Health IT Designers, Testers and Purchasers Trying to Harm Patients? Part 3 of a Series Healthcare Renewal Blog, Tuesday, February 24, 2009. Retrieved on August 15th, 2010 from http://hcrenewal.blogspot.com/2009/02/are-health-it-designers-testers-and_24.html

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Lecture b Images

Slides 5, 7, 8, 10, 14, 15, 16, 18, 22, 29 & 30: Belden, J. (2010). Usability in Health IT: Technical Strategy, Research, and Implementation, National Institute of Standards and Technology Gaithersburg, MD, July 13, 2010. http://www.nist.gov/itl/upload/Final-Agenda-Usability-in-Health-IT-2.pdf

Slide 24: Usability in Health IT: Technical Strategy, Research, and Implementation, National Institute of Standards and Technology Gaithersburg, MD, July 13, 2010. http://www.nist.gov/itl/upload/Final-Agenda-Usability-in-Health-IT-2.pdf

Slides 32, 34 & 35: Promoting Usability in Health Organizations: Initial Steps and Progress Toward a Healthcare Usability Maturity Model HIMSS Usability Task Force 2011 Healthcare Information and Management Systems Society http://www.himss.org/content/files/HIMSS_Promoting_Usability_in_Health_Org.pdf

Slide 38: Rmhermen, 2005. Retrieved, August 10th, 2010 from http://en.wikipedia.org/wiki/File:Late_model_Ford_Model_T.jpg

Slide 39: Sigmund 2007. Retrieved August 10th, 2010 from http://en.wikipedia.org/wiki/File:Oldsmobile_eighty-eight_1958.jpg

Slide 40: Retrieved August 10th, 2010 from http://www.flickr.com/photos/treevillage/3559121095/sizes/l/

Slide 41: R. Sull 2008. Retrieved on August 10th, 2010 from http://en.wikipedia.org/wiki/File:Rotaryphone1.jpg

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Slide 42: Kozuch 2009. Retrieved on August 10th, 2010 form http://en.wikipedia.org/wiki/File:DynaTAC8000X.jpg
Slide 43: Laihu 2001. Retrieved on August 10th, from http://en.wikipedia.org/wiki/File:Galaxy_Nexus_smartphone.jpg

Graphs
Senathirajah, Y. (2010). Creatinine and Renal Function Table. Department of Biomedical Informatics, Columbia University Medical Center. unpublished manuscript.

Lecture c Images
Slide 11: Dish, J.G., Lowry, S.Z., Locke, G., Gallagher, P.D., Friedman, C. (2010). Usability in Health IT: technical strategy, research, and implementation: summary workshop. National Institute of Standards and Technology, U.S., Department of Commerce. Retrieved on September 4th, 2012 from http://www.nist.gov/itl/hit/upload/U-HIT_Workshop_Report_Publication_Version.pdf

Suggested Readings

1. One Insurance company's case descriptions of EHRs causing errors: http://hcrenewal.blogspot.com/2010/07/norcal-mutual-insurance-company.html
   (Scot Silverstein's blog)
2. Electronic Health Records: Recognizing and Managing the Risks "Claims Rx"
   http://www.norcalmutual.com/publications/claimsrx/oct_09.pdf*
3. Presentations on usability by HIMSS members
   http://www.himss.org/ASP/topics_FocusDynamic.asp?faid=358*
4. Nielsen's Ten Usability Heuristics
   http://www.useit.com/papers/heuristic/heuristic_list.html
5. AHRQ usability reports http://healthit.ahrq.gov
6. Research-Based Web Design & Usability Guidelines www.usability.gov/pdfs/guidelines.html and http://Ui-patterns.com
7. Open source standards for medical information display created by National Health Service (Britain) through a rigorous process
   http://Mscui.net
8. Joint Commission: official 'Do Not Use' abbreviations list:
   www.jointcommission.org/NR/rdonlyres/2329F8F5-6Ec5-4E21-B932-54B2B7D53F00/0/dnu_list.pdf*

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9. Site discussing EMR usability, author is Dr. Jeffrey Belden http://www.toomanyclicks.com

Student Application Activities

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comp15_unit6_discuss_key.doc
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Component 15/Unit 7

Unit Title
Clinical Decision Support and Usability

Unit Description
Diagnose problems associated with a clinical decision support system.

Unit Objectives
By the end of this unit the student will be able to:

1. Understand the cognitive basis for decision making and its effect on clinical errors
2. Discuss the role of usability testing, training and implementation of clinical decision support
3. Describe and define usability as it pertains to clinical decision support
4. Identify examples of usability barriers to adoption of clinical decision support
5. Identify a set of well-established principles of usability and design and describe their application to clinical decision support

Unit Topics / Lecture Titles
A. Understanding Human Decision Making
B. Clinical Decision Support Systems (CDSS)
C. Computer Provider Order-Entry Systems and CDSS
D. Promise and pitfalls
E. Factors
F. Barriers
G. Improving Design

Unit References
(All links accessible as of 1/1/2014)

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Slide 18: Retrieved on August 10th, 2010 from http://www.flickr.com/photos/bojo/4078685614/lightbox/#/

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Suggested Readings - None

Student Application Activities

comp15_unit7_discuss.doc
comp15_unit7_discuss_key.doc
comp15_unit7_self-assess.doc
comp15_unit7_self-assess_key.doc

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Component 15/Unit 8

Unit Title
Approaches to Design

Unit Description
Characterize the multifaceted nature of the design process and evaluate whether a given user interface embraces sound principles of design to support usability goals.

Unit Objectives
By the end of this unit the student will be able to:

1. Explain a user-centered design approach
2. Define conceptual models
3. Explain the iterative design process
4. Describe requirements analysis and cognitive task analysis
5. Characterize the role of prototypes in design
6. Describe the principles of participatory design
7. Describe principles of sound design to support usability
8. Describe how Nielsen's heuristics and design principles apply to user interface design
9. Explain the difference between low fidelity and high fidelity prototypes and when it would be appropriate to use one versus the other
10. Unit Topics
    a. Translating requirements into design
    b. Nielsen's heuristics and design principles
    c. Classification exercise (card sorting)
    d. Participatory design
    e. Low fidelity prototypes
    f. High fidelity prototypes
    g. Iterative design

Unit Topics / Lecture Titles
A. User centered design approach; conceptual models
B. Requirements analysis and cognitive task analysisng
C. Iterative design process

Unit References
(All links accessible as of 1/1/2014)

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Lecture a Images

Slide 13: Retrieve August 20th, 2010 from Wikimedia Commons GNU General Public License
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Slide 20: Kaufman, D. (2012). The usability engineering lifecycle. Personal picture- Department of Biomedical Informatics, Columbia University Medical Center.

Lecture b Images
Slide 11 & 12: Starren J, Hripcsak G, Sengupta S, Abbruscato CR, Knudson PE, Weinstock RS, Shea S. Columbia University's Informatics for Diabetes and Telemedicine (IDEATel) Project: technical implementation. JAMIA 2002;9:25-36.
Slide 13: Kaufman D.R., Cronin P., Rozenblit L., Voccola D., Horton A., Shine A., Johnson S.B. (2011). Facilitating the iterative design of informatics tools to advance the science of autism. Studies in Health Technology and Informatics, 69, 955-9.
Slide 15: Kaufman, D. (2012). Plastic Interface for Collaborative Technology Initiative through Video Exploration. Department of Biomedical Informatics, Columbia University Medical Center
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Lecture c Images
Slide 9: Starren J, Hripcsak G, Sengupta S, Abbruscato CR, Knudson PE, Weinstock RS, Shea S. Columbia University's Informatics for Diabetes and Telemedicine (IDEATel) Project: technical implementation. JAMIA 2002;9:25-36.
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Student Application Activities

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comp15_unit8_discuss_key.doc
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Component 15/Unit 9

Unit Title
Ubiquitous Computing

Unit Description
Describe the role of mobile and ubiquitous computing in healthcare

Unit Objectives
By the end of this unit the student will be able to:

1. History of Ubiquitous computing and basic principles
2. Describe the role of mobile and ubiquitous computing in healthcare
3. Describe some of the technical Challenges

Unit Topics / Lecture Titles
A. Context-sensitive applications
B. Mobile platforms in the hospital
C. Information access, decision support and mobile EHRs

Unit References
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Journals/Books

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Images

Slide 5: Image of iPhone ouch screen first generation taken from Apple.com on September 10th, 2010. Image of Motorola flip phone taken from Motorola.com retrieved on September 10th, 2010

Slide 6: Image of Dell computer taken from Dell.com on September 10th, 2012. Ipad image retrieved from Apple.com on September 10th, 2010.

Slide 7: Original vision image retrieved September 10th, 2010 from http://www.telepresenceoptions.com/2011/10/the_worlds_largest_integrated/

Original vision image retrieved September 10th, 2010 from http://www.magic.ubc.ca/wiki/pmwiki.php/Projects/PSPI*.

Slide 8: Version of Ubicomp image from Science Daily, April 28, 2008 (The Prototype Wearable Eye Tracker, image courtesy of ETH Zurich)

Slide 15 & 16: Improving Patient Safety Image from MedGadget, March 22, 2010 (http://medgadget.com/2010/03/rfid_patient_wristbands_safe_for_ct_and_mri.html)

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Suggested Readings
None

Student Application Activities
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comp15_unit9_self-assess.doc
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Component 15/Unit 10

Unit Title
Designing for safety

Unit Description
Diagnose various types of error and create or select potential solutions.

Unit Objectives
By the end of this unit the student will be able to:

1. Define “workflow analysis” and methods for examining and addressing human errors
2. Design a workflow analysis study
3. Identify common sources of error documented in research studies in medicine
4. Apply the cognitive taxonomy of errors
5. Apply principles underlying the design of healthcare systems for safety

Unit Topics / Lecture Titles
A. Workflow analysis
B. Sources of error in medicine
C. The case of intensive care medicine
D. Cognitive taxonomy of error
E. Designing for safety

Unit References
(All links accessible as of 1/1/2014)

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Lecture a Images

Slide 19: Bobb, AM, Payne, TH, Gross, PA. (2007). Viewpoint: controversies surrounding use of order sets for clinical decision support in computerized provider order entry. Journal of the American Medical Informatics Association, Volume: 14, Issue: 1, Publisher: American Medical Informatics Association, Pages: 41-47

Lecture b Tables

Slide 11: Patel VL, Cohen T. (2008). Error in Critical Care. Curr Opin Crit Care. 2008 Aug;14(4):456-9. (slide 11)

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Slide 10: Zhang, J., Patel, L.V., Johnson, R. T., &. Shortliffe, H.E. (2004). A cognitive taxonomy of medical errors. Journal of Biomedical Informatics 37:193–204
Slide 16: Jiajie Zhang, Vimla L. Patel, Todd R. Johnson, and Edward H. Shortliffe. A cognitive taxonomy of medical errors. Journal of Biomedical Informatics 37 (2004) 193–204
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Slide 12: Cohen T, Blatter B, Almeida C, Patel VL. (2007). Reevaluating recovery: perceived violations and preemptive interventions on emergency psychiatry rounds. J Am Med Inform Assoc. 2007 May-Jun;14(3):312-9.
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https://www2.infoway-inforoute.ca/Documents/EHR-Patient%20Safety%20Report.pdf
Accessed Dec 6 2011.

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Component 15/Unit 11

Unit Title
Designing for safety

Unit Description
Diagnose various types of error and create or select potential solutions.

Unit Objectives
By the end of this unit the student will be able to:

1. Define “workflow analysis” and methods for examining and addressing human errors
2. Design a workflow analysis study
3. Identify common sources of error documented in research studies in medicine
4. Apply the cognitive taxonomy of errors
5. Apply principles underlying the design of healthcare systems for safety

Unit Topics / Lecture Titles
A. Workflow analysis
B. Sources of error in medicine
C. The case of intensive care medicine
D. Cognitive taxonomy of error
E. Designing for safety

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Images

Slide 11: Scoble, Robert 2010. http://www.flickr.com/photos/scobleizer/5492884560/in/photostream/
Slide 13: Kirby Lester, LLC. http://en.wikipedia.org/wiki/File:Kirby_Lester_KL60_fully-automated_dispensing_system.jpg
Slide 19: Screenshot from dropdown menu in Microsoft Office Word, 2012.

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Component 15/Unit 12

Unit Title
Information Visualization

Unit Description
Describe how information visualization can support and enhance the representation of trends and aggregate data.

Unit Objectives
By the end of this unit the student will be able to:

1. Identify/describe the role of information visualization and describe its purpose in enhancing usability of health technology.
2. Describe how information visualization can support and enhance the representation of trends and aggregate data

Unit Topics / Lecture Titles
A. Purpose of information visualization
B. Scientific visualization, information visualization
C. Representing trends and aggregate data

Unit References
(All links accessible as of 1/1/2014)

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Slide 17: Scatterplot matrix, retrieved September 10th, 2010 from http://edndoc.esri.com/arcobjects/8.3/Samples/Analysis%20and%20Visualization/Scatterplot/Scatterplot.htm

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Slide 5: Furnas, G. (1986). “Generalized Fisheye Views”, Proceedings of SIGCHI ‘86, New York, pp. 16-23.
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Slide 18: Screenshot of folder structure in Windows Operating System. 2012
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Suggested Readings
None

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Component Acronym Glossary

ADEs- Adverse Drug Events
AHRQ- Association for Research on Healthcare and Quality
ARRA- American Recovery and Reinvestment Act
ATMs- Automatic teller machine
BCMAs- Barcode Medication Administration
BPC- Body position change
CDSS- Clinical Decision Support Systems
CIS-Clinical Information Systems
CM- Conceptual model
CTA- Cognitive Task Analysis
CTICU- Cardio Thoracic Intensive Care Unit
CW- Cognitive Walkthrough
CZ- Critical Zone
DFP- Digital Family Portrait
DM-Decision Making
DSS- Decision Support Systems
DVT prophylaxis- Deep vein Thrombosis Prophylaxis
GPS- Global Positioning system
GUIs- Gestural Interfaces
HCI- Human Computer Interaction
HF- Human factors
INR-International Normalized Ration
IOM- Institute of Medicine
JAMA- Journal of the American Medical Association
JFK- John F. Kennedy Airport (New York, NY)
KCL- Potassium Chloride
LCD- Liquid Crystal Display
LOS- Length of Stay
LTM- Long-term memory
MAHI- Mobile Access to Health Information
MAUDE-Manufacturer and User Facility Device Experience Database
MPH- Miles per hour
MRSA-Methicillin-resistant Staphylococcus Aureus
NASA-National Aeronautics and Space Administration
NPSG 3- National patient safety goals #3
NRC- National Research Council
OT- Occupational therapy
P.O. Fluids (by mouth)- ‘Per os’

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PARC- (Xerox) Palo-Alto Research Center
PCA- Patient controlled analgesics
PDA- Personal digital assistant
PT- Physical therapy
RFID- Radio Frequency Identification Tags
Spd- Speed
TID- Three times a day
TLX- Task Load Index
UAC- Unintended adverse consequences
UBicomp- Ubiquitous computing
UEL- Usability Engineering Lifecycle
UI- User interface
UIC- Unintended consequences
URL- Uniform Resource Locator
WebCIS- Web Clinical Information System
WM- Working memory

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