Appendix 1. Example Educational Objectives

The following objectives were used in the course discussed in the main body: ME 600903 Introduction to Biomedical and Public Health Informatics

Overall skill competency: Identify mismatch between Above the Line need and Below the Line solutions.

Course Learning Objective

- Articulate strategic direction for public health informatics within the enterprise
- Describe components of management tools for the enterprise
- Identify discuss, information, and data needs of project or program users and stakeholders
- Identify core concepts and frameworks in the area of information science, computer science, computer technology and standards
- Recognize core features of procedural programs and web-based technology

Objectives by Week (Level)

Level(s)	Objectives
Technology	• Demonstrate literacy with basic technology terminology • Compare the pros and cons of 4 database classes • Distinguish 3 layers of a relational-database • Distinguish different layers of the networking stack • Define key terms in the standard Web architecture • Describe approaches to computer security over the Web
Data/Information/Knowledge Algorithms	• Identify data, information, knowledge, and wisdom in user interfaces related to health IT • Identify opportunities for amelioration due to errors related to data, information, or knowledge in health IT • Identify uses of data, information, or knowledge • Distinguish data from metadata
Information System Modules	• Recognize a variety of approaches for identifying information needs: evidence-based medicine, least effort, berrypicking, sense-making, small-world exploration, cognitive work analysis, transtheoretical model of behavior change • Identify information needs of health professionals • Read and appraise diagrams (flowcharts, data flow, use-case, activity, and sequence) used in communicating needs, workflows, and processes
Perspective/Roles	• Recognize a variety of approaches for identifying information needs: evidence-based medicine, least effort,

Goals/Functions	berrypicking, sense-making, small-world exploration, cognitive work analysis, transtheoretical model of behavior change
Workflow/Behavior/Adoption	• Identify information needs of health professionals • Read and appraise diagrams (flowcharts, data flow, use-case, activity, and sequence) used in communicating needs, workflows, and processes
World	• Articulate the relationship among healthcare cost, quality, and IT • Describe government EHR incentive programs, successes at adoption, impact, and harms • Match evaluation/assessment frameworks to questions about information ecosystems
Organization	• Identify the organogram for the organization deploying HIT

An publicly-accessible overview of the course syllabus is available through https://courseplus.jhu.edu/core/index.cfm/go/home.onlinecourses/, and scroll to First Term, Introduction to Biomedical and Public Health Informatics. (The URL changes each year.)

Appendix 2: Evaluation and Scientific domains within the Informatics Stack

Level	Example Evaluation Methods		Example Evaluation Targets	Scientific Domain
	Qualitative	Quantitative		
World	• Description	• Indicators		• Health Services Research • Epidemiology
Organization/ Role	• Organogram[1]* • Social network analysis[2]	• Quality Report card • Budget	• Financial goals • Mission goals • Worker Satisfaction	• Management Sciences
Goals/ Functions	• Use Case diagram[3]	• Cluster-randomized trial	• Outcome	• Basic Biomedical Sciences • Clinical sciences
Workflow/ Adoption/ Behavior	• Business process model[4] • Activity Diagram[3] • Cognitive walkthrough[5] • Root Cause Analysis[6]	• Time-Motion study • Fault Tree Analysis[7]	• Process	• Management sciences • Anthropology[8,9] • Implementation science[10] • Cognitive science[11] • Decision science[12] • Sociotechnical analysis[13,14]
Information system	• Structure Diagram[3]	• Performance testing • Functional testing	• End-to-end function	• Software engineering
Module	• Class diagram[3]	• Unit testing	• Output • Unit function	• Software engineering • Bioengineering
Data Information Knowledge Wisdom Algorithms	• Database schema • Information model • Ontology • Theorem proving	• Algorithmic performance	• Coherence • Consistency • Completeness • Correctness	• Philosophy (Epistemology)[15] • Data Science • Computer Science (Software)
Technology	• Meeting qualitative specifications	• Meeting quantitative specifications	• Function	• Computer Science (hardware)

*Citations refer to authoritative sources or classic examples.

References

1. Haskell AC. Graphic charts in business: How to and use them. 1st ed. New York: Code; 1922.
2. Wasserman S, Faust K. Social network analysis methods and applications. New York: Cambridge University Press; 1994.
3. Unified Modeling Language (UML) [Internet]. 2015 [cited 2015 Sep 27]. Available from: http://uml.org/
4. van der Aalst WMP, van Hee K. Workflow Management by Models, Methods, and Systems. Cambridge, MA: MIT Prss; 2004.
5. Zhang J, Walji M. Better EHR: Usability , workflow and cognitive support in electronic health records [Internet]. Houston, TX: Nation Center for Cognitive Information & Decision Making in Healthcare; 2014. Available from: https://sbmi.uth.edu/nccd/better-ehr/
6. Wu AW, Lipshutz AKM, Pronovost PJ, J R, JS C, RA I, et al. Effectiveness and Efficiency of Root Cause Analysis in Medicine. Jama [Internet]. 2008;299(6):685. Available from: http://jama.jamanetwork.com/article.aspx?doi=10.1001/jama.299.6.685
7. Rausand M, Høyland A. System reliability theory : models, statistical methods, and applications. 2nd ed. Hoboken, NJ: Wiley-Interscience; 2004.
8. Forsythe DE, Osheroff JA, Buchanan BG, Miller RA. Expanding the concept of medical information: An observation study of physicians' information needs. Comput Biomed Res. 1992;25(2):181–200.
9. Hartzler A, Pratt W. Managing the personal side of health: how patient expertise differs from the expertise of clinicians. J Med Internet Res. 2011/08/19. 2011;13(3):e62.
10. Druss BG, Dimitropoulos L. Advancing the adoption, integration and testing of technological advancements within existing care systems. Gen Hosp Psychiatry [Internet]. Jan [cited 2015 Oct 19];35(4):345–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23643032
11. Patel VL, Yoskowitz NA, Arocha JF, Shortliffe EH. Cognitive and learning sciences in biomedical and health instructional design: A review with lessons for biomedical informatics education. J Biomed Inform [Internet]. 2009 Mar [cited 2015 Jun 30];42(1):176–97. Available from: http://www.ncbi.nlm.nih.gov/pubmed/19135173
12. Hunink MGM, Weinstein MC, Wittenberg E, Drummond MF, Pliskin JS, Wong JB, et al. Decision Making in Health and Medicine: Integrating Evidence and Values. 2nd ed. New York: Cambridge University Press; 2014.
13. Carayon P, Bass E, Bellandi T, Gurses A, Hallbeck S, Mollo V. Socio-Technical Systems Analysis in Health Care: A Research Agenda. IIE Trans Healthc Syst Eng [Internet]. 2011;1(1):145–60. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3351758&tool=pmcentrez&rendertype=abstract
14. Whetton S. Health informatics : a socio-technical perspective. Oxford ;;New York: Oxford University Press; 2005.
15. Munn K, Smith B. Applied ontology : an introduction. Frankfurt ;Piscataway NJ: Ontos Verlag; 2008.

Appendix 3:
Final Project Template

Project Management (100 points: Organization, following instructions, keeping milestones, group work)

- Provide the name the system.
- Present a table with milestones, due dates, and dates the milestones were achieved.
- List the two perspectives and functions you will "follow down the Stack" of the Project.
- List any collaboration activities (phone calls, chats, etc.).

As you go through this Project, make sure that any text you take from the source report (e.g., Davies report) is enclosed in quotation marks. We need to know what is your data and what is your inference.

System Name:

Write in here:

Milestones:

Date*	**Milestone Number**	**Milestone** (Suggested: feel free to modify)	Who is responsible? (Write in initial assignments)
9/16	-----	Group assignment completed	
9/19	Milestone 1	Group's topic (i.e., Davies winner) posted on Group wiki; Project Management (who does what)	
9/21	Milestone 2	Specify function (on project management page) [see sidebar "About Functions"]	
10/3	Milestone 3	World, Organization, Perspectives/Roles, Functions	
10/10	Milestone 4	Information system, modules, Data/Information/Knowledge, Output/Outcomes	
10/17	Milestone 5	Testing, Evaluation, Hardware/Technology	

10/19	Milestone 6	Workflow, Software development, Other, Reflection Wiki finalized	
10/22	Milestone 7	Peer evaluation completed (Fellow group member; other wiki)	

*All times are 11:59 pm Eastern time

Collaboration Log:

Write in here as you go along

Introduction (10 pt)

- Edit the following. Feel free to modify it in the course of completing the Project, including the day before closing it.

This Project concerns the organization, <write here the name of the organization>, who implemented the <name of the system>. This organization is functioning in the context of the "world" of <precis of the World>, with the specific challenges of <name of the problem>. While there are many stakeholders involved in this problem and the use of the system as a solution, this report focuses on two perspectives <Perspective #1> and <Perspective#2>, whose primary goals, with regard to the general problem and this system, are <Goal 1> and <Goal 2>. The organization was tacking a number of functions, namely <general functions.> We focus on two primary functions to accomplish the goals of our perspectives, <Function1> and <Function 2>. (A <retain the correct word: clinical | public health> function is also considered, <name of that alternative Function>.) We present a description of those Functions, as well as depict its Workflow, and provide an example of the user's interaction with the system, including the cognitive processes involved. We describe the system put into place, and how it works to support that Workflow and the Functions. We also describe the modules comprising the system, and how they, themselves, are "systems" in their own right. We describe the data, information, knowledge and algorithms employed by the modules and the system to support those functions, as well as the core technologies used to implement the system.

We describe the software development process that was involved <to the extent of the data available>. This development includes any approaches to change management. We articulate the outputs and outcomes of the Functions that <can be | were> used to <confirm success | demonstrate failure> to achieve the goals, and the methods by which those outputs and outcomes were assessed. As part of

"evaluation," we include the testing that <was | should have been> done to determine that the system could accomplish the Functions, whether or not they succeeded at them.

We consider the standards in the system from each level of the Stack, in the context of interoperability. We also describe the privacy, confidentiality, and security concerns addressed and any ethical issues either explicit or implicit in their report.

We close with our individual assessments of the completeness of this report itself, as well as our judgment on whether an award was warranted.

World (10 pt)

- The system you will be describing was put together in order to address a problem. On this page, you describe the larger context of that problem (beyond the Organization).
- What is the external context of the Organization? (E.g, what area of healthcare or public health is involved. Don't describe the Organization in detail at this point.)
- What is the general problem the system was designed to address?
- What were the drivers that made the organization tackle this problem when they did, rather than earlier or later?
- How did these two contexts affect choices made by the Organization in the choice of functions, design, deployment, or use of the information sysem? (Explain the link between the context and any specifics you name or list. You may end up modifying this entry as you go along.)
- How might MACRA (for clinical systems) affect these choices and design, moving forward? (For public health, are there current legislation or regulations that are comparably relevant, and how might they affect your public health system?) You will probably write this paragraph when you are nearly done with the Project.

Organization (10 pt)

- Name the organization
- What is the mission statement (if provided) of the Organization?
- What is the basic structure of the Organization? If there's an organogram (diagram of the organization), insert it here (using the Picture tool, in the editing bar).
- What was the problem the system was designed to address, as it related to the Organization?
- What are key attributes of the organization that are relevant for this problem, and how are they key: what enablers/barriers do they provide?
- What organizational issues (barriers) did the developers/champions deal with and how did they do so? (Don't go into the entire software development process; you'll do that elsewhere.)

Perspectives/Roles (10 pt)

- Who are the key participants and stakeholders discussed in the report?
- List 2 stakeholders/perspectives---expressed in terms of a specific type of person---who you will "follow" down the Stack; if possible, one clinical and one public health perspective. Copy these perspectives to the Project Management page, in the entry space below the Project Management table. Perspectives like, "public health" is too vague; you need to articulate a specific person. (For public health, would that be the epidemiologist? The Health Officer? Some other official?) Being clear is important, because decision support----an important affordance of an electronic health record---must be directed at (and designed for) and individual human being, to be effective.
- Explain whether these roles are primary or secondary stakeholders. (E.g., in a surveillance system, a patient is a secondary stakeholder).
- Explain why you chose them
- Even if you don't have a public health perspective, say something about the public health *role* of the organization. (If your organization is a public health organization, say something about its clinical role.)

Functions (goals/objectives) (20 pt)

- Write the problem as objectives: "To minimize...", "to maximize..."
- Use medical/public health technical terms ["above the line"] in explaining the problem/objectives. If there are many objectives, limit to the "perspectives" you chose in the higher level.
- Name the two functions (one for each perspective that were named in Perspectives) that are/were crucial to addressing the problem. Express them as, shall be able to . E.g., patient shall be able to participate in her care. You will follow these two functions down the Stack. Copy these functions to the Project Management page.
- The following may not be directly relevant to your problem/functions, but answer them nonetheless.
    - What Stage 1 Meaningful Use criteria were addressed by the system (even if it's after the fact)?
    - What Stage 2 criteria?
    - What other "business process" issues were addressed?
- If this is a clinical project, name a public health function that the clinical project could support/enhance, indexed to a Public Health Essential Function; if a public health project, name a clinical function that the public health project could support/enhance (which could go beyond Menaingful Use).

Workflow/Behavior (40 pt)

- How do the authors describe the workflow of your two functions?
- Use two swimlane diagrams to describe the workflow of each of your functions.
    - Name the function in a legend (above or below the diagrams).
    - Include each relevant participant in the function, besides "your" perspective.
    - Include the information system as one participant. (If an HIE is involved, the HIE should get a swimlane of its own, as well.)
    - We don't expect more than 3 or 4 boxes or diamonds in each row.
    - A "box" (or diamond, for decisions) should start with a verb, whose subject is the name of the row. (E.g., Logs In; Authenticates physician; ...)
    - Under the diagram, indicate what tool you used. (We will share this information with next year's students.)
- What cognitive user needs/behaviors did the system or the developers address in the interaction with the system and which framework (e.g., Transtheoretic Model...) would you use to characterize how they addressed that interaction (and not the adoption) for one of the two functions.
    - You should critique a screen shot in terms of the cognitive strategy, if easily available.

- Otherwise, discuss the function. (This task is NOT about adoption.)

Information system (30 pt)

- System Description, focusing, if the system is too big, on the two functions:
  - Provide an IT-jargon-free description of the target solution (written by the least clinical/public health person of the group)
  - Provide an IT-jargon-full description of the target solution (written by the least IT person of the group); focus on the logical architecture and avoid getting into the weeds of the hardware; that's for later. In both, focus on the issue of integration/interoperability (appearance of the system as a coherent whole.)
  - What does each description add? What does it miss?
- What non-functional specs were expressed in the report? (Choose the most important from the list on wikipedia.)
- What standards were used for the integration, stratified by the classes of standards presented in the PowerPoints (technology, DIKW, module/information system, workflow, roles, organization)?
  - They may not have used standards at each level or they may not have indicated what the standard was. Make an educated guess, if there is no indication (and explain your guess.)

Modules (20 pt)

- What component systems does the report identify, especially to support the two functions?
- How were they integrated together?
- How are they systems in their own right?

Data/Information/Knowledge (20 pt)

- What data are the focus of the system, especially in terms of the two functions? What are their data types (numeric, text/atomic, free text)?
- What interpretations/information is created from those data?
- What knowledge/rules are used?
- Are any algorithms mentioned for either turning data into information, or for deriving or using knowledge? If not, what algorithms do you judge to be there implicitly?
- How was data (information, and knowledge, as well) quality addressed, if at all?

Hardware/Technology (10 pt)

- What technologies were used, especially in terms of the two functions? Mention technology explicitly included. If there is a deployment diagram (i.e., what hardware components are connected to what components through what network), include that. (Don't create do novo.)
- What is the relationship between the hardware/technology and the DIKW or modules?

Software development (10 pt)

- What does the report say about

    - How requirements were collected? What strengths/weaknesses are evident from their description of the requirements collection process?
    - How system development was managed?
    - How was adoption and change management addressed?
    - How expected user behaviors (including rejection) were addressed?
- What informatics personnel/skills seem to have been involved?
- (If there is specific information related to the two functions, highlight that information.)

Testing, Evaluation (10 pt)

- In this page, you will write *how* the outputs and outcomes were assessed:
- How did they know that the software worked as desired (what process did they use for testing)?
- How did they know that the software achieved the goals addressed in Functions (Objectives; the 2 functions)(evaluation)
    - What monitoring metrics/indicators were used and reported?
    - What summative/evaluative indicators were used and reported?
    - What method(s) of evaluating (with respect to high-level objectives) are reported? What were the results? Are you convinced?
- Do you have any data to make a cost (of deployment, etc.)-benefit (of outcomes) assessment? What is your conclusion?

Outputs and outcomes and unintended consequences (20 pt)

- Review the presentation on the LogFrame for examples of ouputs vs outcomes. (i.e., output is what the system produces (e.g., drug-drug interaction alerts). Outcome is the result of those outputs (e.g., reduced drug-induced adverse events).
- What outputs (generally, process outcomes or behaviors) were their focus, altogether and in terms of the two functions?

- What outcomes (generally, health outcomes of patients or the public)?
    - [Note that in Testing and Evaluation, you'll describe *how* the outcomes/outputs were elicited from the system.]
- Do you believe that the outputs you listed are relevant to the outcomes you listed? Why (or why not)?
- Do you believe that the outcomes are relevant to the higher-level "objectives" you listed in the "Functions" section? Why (or why not)?
- Did they put in place a process to know about unintended consequences? Did they report any? What were they?

Interoperability (10 pt)

In general, with what other information systems does this one interoperate? (In general, and then focused on your two functions.)

To what extent and how are the organizations integrated? [What agreements/policies/contracts are there between the organizations, above the line.]

For the following levels of the Stack, what standards/modes are used to interoperate?

- Organization
- Workflow
- IS
- DKIW
- Technology

Privacy, Confidentiality, Security (10 pt)

- What privacy policies were instituted at the Organization level?
- How was confidentiality protected in the Workflow?
- What security protections were place at the Technology/Modules levels?

Ethical concerns (10 pt)

- What ethical concerns were addressed explicitly in the report or that you found implicit in the project, beyond data-privacy issues?
    - In bioethics, we focus on 4 principles: respect for persons (autonomy), beneficence, non-maleficence (do no harm), and justice. (Source) In informatics, there are also issues of power (who owns the data), which, I suppose, is a justice issue.

Reflection (10 pt)

- What does each group member feel they would have missed without using these frameworks (i.e., did you find any surprises?)
- What does each group member feel should be addressed, but is missed by these frameworks? (Focus on what the frameworks are missing, not what the report is missing.)
- What does each group member think about the award or attention the system received: Deserved or not?