Use of Curriculum Mapping Tools to Identify Learning Opportunities and Deficiencies II: KnowledgeMap

Josh Denny, MD, MS
March 7, 2013
The Flexner Report

- Medical education in the United States and Canada, 1910
- Set the foundation for modern medical education
- Current pressures challenge this model:
  - “publish or perish” (researcher)
  - Demand on throughput (clinician)
Part #1: Assessing Curricula

- LCME and ACGME require increasing documentation of curriculum objectives, coverage, and student patient experiences
- Accreditation standards specific content, competencies, amount of training, etc. for periodic reviews
- ED-2:
  
  “The institution that offers a medical education program is required to establish a system to specify the types of patients or clinical conditions that medical students must encounter and to monitor and verify the medical students' experiences with patients so as to remedy any identified gaps.”
Traditional Medical Education Model

First year

Second year

USMLE Board Exams

Clinical education

Patients
Guiding questions

- **Faculty**: “I am teaching about congestive heart disease – what have students already learned about this?”

- **Students**: Studying immunoglobulins, need to find relevant prior concepts like splicing

- **Administrators**: Where do we cover large concepts, like geriatrics?
Traditional Solutions

- Web pages for courses
- Course management software (Blackboard, WebCT)
- Finding what is taught where:
  - Curriculum committee meetings
  - Emails
  - Manual logs
  - External, manually maintained curricular databases such as CurrMIT
An Informatics Model

- Let learners access work at their own rate (finding old and new data)
- Use multiple methods to delivery content
- Faculty are busy – focus on easing content capture, and create tools to accurately capture
- Provide robust searching tools across the entire curriculum
Courses grouped by years, with calendars specific for each year.

Supports multiple “programs” (Med school, residencies, etc).
2007/2008 Structure, Function & Development Schedule

Course Links: Gross Anatomy sessions | Cell Biology sessions

Labels: Exam or Quiz | Physiology | Gross Anatomy | Cell Biology

### Unit #1

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Location</th>
<th>Title</th>
<th>Lecturer</th>
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<tr>
<td>10/25</td>
<td>08:00 AM - 08:30 AM</td>
<td>LH 202</td>
<td>Introduction</td>
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<td>Layered &amp; Segmented Structure of body; Intro to Nerves &amp; Nerve Classification; Simple Spinal n.</td>
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<td>GA Lab: Deep Back (Perform Laminectomy)</td>
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<td>Overview of Lymphatic System; Principles of Collateral Circulation</td>
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<td>GA Lab: Complete Dissection of Deep Back; Pectoral Region, Including Removal of Skin from Arm (Excluding Female Breast)</td>
<td>Arthur F Dalley</td>
</tr>
</tbody>
</table>
Faculty upload native formats (e.g., PowerPoint) and KM creates other formats automatically.
Document Processing

Document uploaded by lecturer, placed in queue

Document Conversion Server pulls next document off queue, converts to HTML and Text

Web server

HTML & PDF versions

Text version placed in queue

KM Concept Identifier

Identified concepts indexed for searching

PDF, MS Word, WordPerfect, HTML, PowerPoint, etc
Concept vs. Text indexing

- **Text indexing**
  - Indexing by words of document
  - “Hepatolenticular degeneration” ≠ “Wilson’s Disease”

- **Concept indexing / Natural language processing**
  - Recognizes words in document to a controlled vocabulary
    - Unified Medical Language System, contains >100 vocabularies, >2 million concepts mapped to >8 million English synonyms)
  - “Hepatolenticular degeneration” = “Wilson’s disease”
  - Figures out ambiguous concepts:
    - “CHF” – “Congestive Heart Failure” or “Congenital Hepatic Fibrosis”?
    - “BSE” – “Bovine spongiform encephalopathy” or “Breast self exam”
  - Interprets phrases
    - “The aortic valve was stenosed” = “aortic stenosis”
    - “gram negative infection” = “gram-negative bacterial infection”
Analysis of first ~60,000 searches showed that 85% were medical concepts.
Documents containing the concept “urinary incontinence”
Slide #92: "Urinary Incontinence"

- Stress incontinence
- Urge incontinence
- Mixed incontinence

Slide #93: "Incontinence"

The involuntary loss of urine

- Stress incontinence (SUI): occurs with increases in intraabdominal pressure
- Urge incontinence (UUI): leakage that is preceded by an intense uncontrollable urge to void
- Mixed incontinence: both SUI and UUI

Slide #94: "Components of a Thorough Evaluation"

- Detailed history
- Questionnaire
- Physical examination
- Other testing: UA, voiding diaries, pad test, uroflow, postvoid residual (PVR), urodynamics

* Recommended minimal standards for pretx eval by AUA
Definitions for "chf"

KnowledgeMap Definitions:

**Congenital hepatic fibrosis** [Approx. 6 documents in KM]: no definition

**Congestive heart failure** [Approx. 281 documents in KM]: Weakness of the heart muscle that leads to a buildup of fluid in body tissues.

**Hemorrhagic Fever, Crimean** [no documents]: A severe, often fatal disease in humans caused by the Crimean-Congo hemorrhagic fever virus (HEMORRHAGIC FEVER VIRUS, CRIMEAN-CONGO).

Three definitions for “CHF” – the system disambiguates each occurrence of “CHF” into one of these three matches when in documents
CONGESTIVE HEART FAILURE

Heart failure exists when the heart does not provide enough blood flow to meet the body's needs. This state causes congestion of the tissues, leading to shortness of breath and other symptoms.

It produces the clinical syndrome of dyspnea, peripheral edema, and pulmonary edema. CHF is the pathological state in which an abnormality of myocardial function is responsible for the failure of the heart to pump at a rate commensurate with the requirements of metabolizing tissues. CHF is encountered frequently by the clinician; it accounts for 2% of all hospital admissions and carries a 5-year survival rate of <50%.

I. CAUSES OF CONGESTIVE HEART FAILURE

A. Myocardial Disease (pump defect)
   1. Coronary heart disease -- myocardium is impaired by ischemia
   2. Cardiomyopathy -- intrinsic myocardial defect
   3. Infiltrative diseases:
      amyloidosis
      sarcoidosis
      myocarditis

B. Excessive Workload due to:
   1. Increased resistance to ejection which can be due to pressure overload, hypertension, aortic or pulmonary stenosis, or hypertrophic cardiomyopathy.
   2. Increased stroke volume, volume overload which can be due to aortic, mitral or tricuspid insufficiency or congenital left-to-right shunts.
   3. Increased body demands (high output failure); can occur with thyrotoxicosis, anemia, pregnancy, or arteriovenous fistulas (abnormal shunt between an artery and vein which increases venous return and decreases oxygen delivery to shunted area).
Infantile Polycystic Kidney Disease (Autosomal Recessive Polycystic Kidney Disease, ARPKD)

I. General and clinical features:
   A. Incidence and relationship to congenital hepatic fibrosis: Infantile polycystic kidney disease is closely associated with congenital hepatic fibrosis (CHF). CHF is an important cause of portal hypertension in children and adolescents. In general, in patients who present as neonates and infants, the clinical picture is dominated by renal failure. Patients who present later tend to have liver problems as the major clinical feature. Although at one time thought to represent distinct disorders, different affected members in the same family may present at different ages with either predominant renal or liver abnormalities, attesting to the underlying genetic relationship of these diseases.

   Infantile polycystic kidney disease is inherited in an autosomal recessive manner (i.e., parents are not affected), with the reported incidence varying from 16,000 to 140,000.

   B. Clinical presentation: Can present at any time in early childhood, but is most common in the first 6 months of life or shortly after birth.

   Can be suspected during prenatal ultrasound secondary to associated oligohydramnios.

   Presentation shortly after birth can be due to polyuria and polydipsia.

   Presentation later in infancy can be due to dehydration (especially during intercurrent illness).

   The kidneys may be sufficiently enlarged to result in a palpable mass. Deteriorating renal function is inevitable, and patients may present later with renal failure/uremia/hypertension.

   As implied above, patients presenting in later childhood and early adulthood usually present with signs of liver involvement, particularly portal hypertension, which may result in hepatosplenomegaly and bleeding esophageal varices.

II. Pathogenesis:
   Recent data has mapped a gene for ARPKD to the short arm of chromosome 6. The specific gene has not been identified.
How do we find broad concepts like “geriatrics” or “women’s health”? 
180 concepts related to "Geriatrics"

1. Deselect Any Incorrect Terms:
   - Geriatrics [Biomedical Occupation or Discipline]
   - Elderly [Temporal Concept]

2. Type Any Additional Terms (one per line):

3. Expand Top 15 Lectures from 2006/2007 Course Year Documents

4. Submit:
   - Expand: See more concepts
   - Finalize: Get Document Matches

Options:
- Show MeSH Concepts Only
- Show semantic types for all concepts
Concepts related to "Geriatrics"

180 Expanded Concepts:

- Mestranol 0.15 MG
- Autobiographical memory
- Senility
- Care given by nurses
- [D]Senility, without mention of psychosis
- Reminiscence
- [D]Senility, without psychosis NOS
- Geriatric Nursing
- Death of relative
- alcohol use disorder in the elderly
- ORTHO-CEPT TAB, 28
- Therapeutic procedure
- Geriatric Assessment
- CARBAMIDE PEROXIDE 10%/GLYCERIN DROPS, ORAL
- Alzheimer's Disease
- Aging and Nutrition
- CONSULTATION NOTE: FINDING: POINT IN TIME: {SETTING}: DOCUMENT: GERONTOLOGY
- DESOGESTREL 0.1-0.15 MG
- Demulen 1/35-28
- Animal-assisted therapy
Searching for documents matching those 180 Geriatric concepts.
Lecture: Aging and Alzheimer's Disease I

NORMAL AGING OF THE BRAIN/ALZHEIMER'S DISEASE

Insight into aging of the brain and Alzheimer's disease is the result of a massive research effort, work on Alzheimer's disease, in particular, represents a rapidly evolving area of research; new and often conflicting data are generated daily; the purpose of this set of lectures is to provide you with the requisite background information necessary to allow you to continue to assimilate new findings as they are generated, and to provide you with a synopsis of both an historical and current (albeit changing) understanding of Alzheimer's disease.

* Recommended reading:

"DeBaggio, Thomas. Losing My Mind. The Free Press, 2002"

"Bayley, John. Elegy for Iris. Picador Press, 1999"

"Jozefowicz and Holloway. Case 26 "The Gopher Hunter""

I. Maturational events which occur normally in the nervous system
How well does KM find metaconcepts?

- Identified gold standard set of 380 documents as containing high, medium or low relevance to each topic.
- Used KM to generate a variable number of subconcepts for each broad concept and calculated a relevance score for each document.

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<td>Women’s Health</td>
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<td>Dermatology</td>
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<td>Radiology</td>
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</table>

Denny, Smithers, Armstrong, Spickard, JGIM, Oct, 2005
Finding broad curricular topics

- Used for LCME, creating/rearranging courses, revising curriculum

Using to infuse Geriatrics in the curriculum:

![Graph showing the number of lectures with Geriatrics from 2002 to 2009, with different Volumes (VMS I, VMS II, VMS III, VMS IV) and the year of start of Geriatrics initiative.](image-url)
KM has been adopted by others
POGOe.org, a free geriatrics site based on KM

- Funded by ADGAP and Reynolds Foundation
- >10,000 users in 174 countries
- 875 published products (free)
- Video, image libraries
- Quizzes
- EBM content
Part #2: Assessment in Clinical Years

- Testing based: USMLE, NCLEX, Residency Board Exams
- Experience Based:
  - ACGME and RRC
  - Nursing requirements
- Both current methods tend to aggregate at high levels
- Experience is an important part of competency
Components of “Learning Portfolio”

- Clinical notes
- Mentor feedback on notes and other documents
- Logs of procedures/patients
- Reflections
- Tests/academic work
- Essays and other documents

We will focus on these
Learning Portfolio – leveraging EMR to capture experience

- Trainee creates note in the EMR
- Electronic Medical Record
- Appropriate mentors emailed (students)
- Mentors evaluate and:
  1. Give feedback
  2. Assign learning objectives
- Automatically Log Procedures
- Use Natural Language Processing to find note content
- Database of concepts
Teachers have students/trainees they “mentor”

What documents/patients they see (for patient confidentiality) is driven by:

- Mentorship type
- Timeframe of mentorship
# Existing Notes

You have **653** notes.

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Note Comments: Medical Student Admission History and Physical

Learning Objectives covered: Cough

General Comments: [Anonymous, attending] Excellent writeup - a few minor points to consider - see comments in text.

Document comments: scroll over comments in yellow

Vanderbilt University Medical Center: [Redacted]

MEDICAL STUDENT

Admission History and Physical

MR#: [Redacted]
Case#: [Redacted]

Date of services: [Redacted]
Primary Care Physician: [Redacted]

Chief Complaint: fever, cough, chest pain

History of present illness:

Mr. [Redacted] is a [Redacted] year old male with PMH significant for HIV (VL 67,000 & CD4 329 in 6/05, last CD4 286 per ptl, no TB (received 6 mo treatment w/ 4 months of chronic back pain who presents with sputum, and chest pain 3/2 cough.

Health until approximately 1.5 yrs ago became more incessant, and he started to occurred simultaneously with his cough.

He has been coughing up yellow-green tinged mucous. He developed fever as high as 102 a few days ago at home and began experiencing a sore throat, headache, arthralgias, and myalgias. He has taken tylex at home, but it has not alleviated his symptoms. He says he has mild diarrhea for a few days prior to developing fever, but he denies having abdominal pain, N/V, or blood in his stool. He says he has had chronic dysuria for 3-4 yrs., but he denies burning with urination or frequency. He has not been taking good po for the past few days, and feels has lost weight over the past few months. He denies sick contacts (besides his partner who has known MAC infection), recent travel, or exposure to animals. He started a new ART regimen approximately 3 months ago including tenofovir, ritonavir and atazanavir, and didanosine.
RCT evaluation of mentor feedback on student notes

Survey of Residents and Attending physicians

<table>
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<th>Compared with prior rotations:</th>
<th>Electronic</th>
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Analysis of student write-ups

- Evaluated 142 write-ups using 13-point rating scale
- Performance on “Assessment and Plan” ratings improved in electronic feedback group (p=0.036)

Spickard et al. J Gen Int Med. 2008;23(7):979-84
Procedures tracked by notes created, and managed/viewed by residencies or clerkships (also used to track some diagnoses)

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# Tracking experience: Vanderbilt Core Clinical Curriculum (VC3)

## 25 Core Clinical Problems (CCP)

<table>
<thead>
<tr>
<th>Abdominal pain</th>
<th>Headache</th>
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<td>Abnormal uterine bleeding</td>
<td>Jaundice</td>
</tr>
<tr>
<td>Abnormal vaginal discharge</td>
<td>Loss of consciousness</td>
</tr>
<tr>
<td>Abnormalities of mood</td>
<td>Obesity</td>
</tr>
<tr>
<td>Altered mental status</td>
<td>Pelvic pain</td>
</tr>
<tr>
<td>Back pain</td>
<td>Pharyngitis</td>
</tr>
<tr>
<td>Breast disease</td>
<td>Rash</td>
</tr>
<tr>
<td>Chest pain</td>
<td>Seizures</td>
</tr>
<tr>
<td>Cough</td>
<td>Shock</td>
</tr>
<tr>
<td>Dysuria</td>
<td>Shortness of breath</td>
</tr>
<tr>
<td>Fever</td>
<td>Substance abuse</td>
</tr>
<tr>
<td>GI bleeding</td>
<td>Trauma</td>
</tr>
<tr>
<td></td>
<td>Weight loss</td>
</tr>
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</table>
Extracting “knowledge” from clinical notes

H&P entered by user

CC: SOB
HPI: This is a 65yo w/ h/o CHF, … no chest pain
...

Clinical Note Section Tagger

<chief_complaint>
  SOB
</chief_complaint>

<history_present_illness>
  This is a 65yo w/ h/o CHF.... Denies chest pain.
</history_present_illness>

KnowledgeMap Concept Identifier

Structured Output
Text labeled with Unified Medical Language System concepts, organized by section

<chief_complaint>
  C0392680: Shortness of Breath
</chief_complaint>

<history_present_illness>
  C0018802: Congestive Heart Failure
  C0008031: Chest Pain, Negated
</history_present_illness>

Denny et al. JAMIA 2003, 2009; AMIA 2008; JBI 2009
Xu et al. JAMIA 2010
Doan et al. JAMIA 2010
Student view of how many VC3 topics they’ve completed. (Teachers can see this also.)

Mapping of a note to a VC3 topic happens **manually** and **automatically** for high scoring documents.

### Learning Objectives

<table>
<thead>
<tr>
<th>Learning Objective</th>
<th>Date Recorded</th>
<th>Event Recorded</th>
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<tr>
<td>Abdominal Pain</td>
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<td>Pediatric Surgery Consultation Note - Medical Student Admission History and Physical</td>
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<td>Pelvic pain</td>
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<tr>
<td>Pharyngitis</td>
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</table>
Searching for relevant notes matching core objective “Back Pain”

He discussed these concepts

...in these sections
Part #3: Evaluating and integrating

Study 1: Curriculum vs. Notes

Learning Portfolio (clinical notes)

CC: abdominal pain
This is a 78yo with PMH significant for who presents with back pain after a fall...

Concept database

Natural language processing

KnowledgeMap (curriculum documents)

PowerPoint slides, lecture notes, etc.

Clinical content filters
- 25 VC3 problems (CCPs)
- 7 types of infections

Compare content, identify discrepancies
Coverage of VC3 Topics

Concept density

Clinical Notes
Curriculum documents

Abdominal Pain
Abnl Uterine Bleeding
Abnl Mood
Abnl Weight Loss
Altered Mental Status
Back Pain
Breast Disease
Chest Pain
Cough
Dysuria
GI Bleed
Fever
Headache
Jaundice
Loss of Consciousness
Obesity
Pharyngitis
Pelvic Pain
Seizures
Shock
Rash
Shortness of Breath
Substance Abuse
Trauma
Vaginal Discharge

300k notes
15k lecture documents

Denny et al. AMIA 2010
Coverage of Infectious Diseases

Curriculum Documents

- Bacteria: 38%
- Virii: 27%
- Fungi: 11%
- Tick-borne: 7%
- Protozoan: 7%
- Helminths: 6%
- Prions: 4%

Clinical Notes

- Bacteria: 60.8%
- Virii: 22.2%
- Fungi: 11.8%
- Tick-borne: 2.1%
- Protozoans: 1.7%
- Helminths: 1.3%
- Prions: 0.1%

Denny et al. AMIA 2010
Study 2: Automated Education Advisors

Student types a note in the EMR

NLP

Database of Note Concepts

NLP Rules Engine

Customized Emails
- Key facts about the diagnosis
- Whether or not they met some criteria
- Links to key references about the topic (on KM)
- Links to documents most relevant to their note

Current Email Advisors:
- Advanced directives (pts > 65, if they don’t mention them)
- Altered mental status (must say AMS concept in key section of note)
CHIEF COMPLAINT: confusion, weakness, and lethargy
HISTORY OF PRESENT ILLNESS: Mrs. X is a 70 year old female with metastatic undifferentiated carcinoma, likely lung in origin, who was recently discharged from the hospital s/p left femoral fracture and biopsy due to a fracture who now presents with increasing confusion, weakness, and lethargy.

PHYSICAL EXAMINATION: General: waxing and waning alertness,

SUMMARY: This is a 72 year old female with metastatic lung carcinoma admitted for delirium most likely secondary to hypercalcemia.

ASSESSMENT AND PLAN:
1. Hypercalcemia Hyperparathyroidism... malignancy...
6. Disp -Will keep hospitalized until altered mental status improves...
CHIEF COMPLAINT: confusion, weakness, and lethargy

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PHYSICAL EXAMINATION: General: waxing and waning alertness

SUMMARY: This is a 72 year old female with metastatic lung carcinoma admitted for delirium most likely secondary to hypercalcemia.

ASSESSMENT AND PLAN:
1. Hypercalcemia
2. Hyperparathyroidism
3. Malignancy
4. Disposition
5. Will keep hospitalized until altered mental status improves

You are getting this email as part of a project to improve your understanding of altered mental status. This email is generated based on your note: Medical Student Admission History and Physical, written on 2011-01-15 19:42:15.

Key facts about Altered Mental Status:
• The differential diagnosis of altered mental status is extensive including dementia, delirium, substance induced, drug side effects, infection, intracranial lesions or strokes, trauma, and metabolic entities such as liver disease or hypoglycemia.
• Alzheimer’s disease, vascular dementia, and dementia with Lewy bodies are the most common forms of degenerative dementias seen in late life.

KM documents most like yours:
• Typical Laboratory Results in the Differential Diagnosis of Hypercalcemia | Joshua Charles Denny | Geriatrics Review Syllabus (Geriatrics)
• Hypercalcemia | Natasha Janelle Schneider | Outpatient Medicine Curriculum (Core Lecture Series)
• Fluid Management for Students | Kyle Bertram Brothers | Pediatrics (VMS III)
• Pharmacological Concepts | Joseph A Awad | Pharmacology (VMS II)

Other searches that may be relevant to this patient:
• Differential diagnosis of metabolic (liver ds, electrolytes, glucose abnormalities) as causes of AMS. (4 overlapping concepts)
• Differential diagnosis of delirium as a cause of AMS. (2 overlapping concepts)
• Signs and symptoms of AMS (2 overlapping concepts)
• Evaluation of AMS (1 overlapping concepts)
Acknowledgements

System Design and Research

- Anderson Spickard, III, MD MS
- Toufeeq Ahmed, PhD, MS
- Randy Miller, MD
- Jeff Smithers, MD
- Peter Speltz
- Glenn Stein, MS
- Terry Payne
- Lisa Bastarache, MS

Support

- Vanderbilt Dean’s Office
- National Library of Medicine
- Reynolds Foundation
- National Board of Medical Examiners
Questions?