Custom Software in Clinical Workflow Management

Pathology Informatics 2012
Tuesday, October 9, 2012

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Workflow and Computers

• Whereas the “overall” workflow in Anatomic Pathology labs is similar from lab-to-lab, the details of the workflow in any particular lab have unique subtleties adapted to the local environment, people, and clinical demands

• Computer software can control, constrain, direct, and drive workflow

• Do we adapt our workflow to the idiosyncrasies of our computer systems, or do we redesign the software to efficiently serve the workflow we feel best serves our needs?
Take Home Messages

- Operational improvements can be obtained through the use of customized informatics tools
- Those tools do not all have to be integrated into the Laboratory Information System
- Where possible, custom tools should be designed philosophically to move the work forward rather than simply keeping track of what work was already done
- Investments in “customized” solutions can be incrementally expanded to address other problems
The Gap

• LISs are at the core of the day-to-day operations in a clinical laboratory

• Most LISs do not fully meet all of the data and workflow management needs of every laboratory
  • LISs designed for the “average environment”
  • Specialty services
  • Complex and unique environments, people, politics

• Options for filling the gap
  1. Make do; adapt the workflow to the computer
  2. Purchase a new LIS
  3. Contract with the LIS vendor to modify/enhance the LIS
  4. Purchase third party software to meet the need
  5. Develop custom software in-house

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Buy vs Build

• Certainly, due diligence demands investigating the availability of a purchasable solution before embarking on any custom development
  • How good is the fit with your workflow?
  • Is it cost prohibitive?
  • Has it been successful in similar environments?
  • What are the hidden costs of purchasing it?
    • Installation, hardware, workflow adjustments, personnel changes, specific consumables, annual maintenance (22-25%!)

• Departmental and Institutional Philosophy is often the major driving factor/inhibitor
  • Administration is “taught” that customizations lead to implementation failure - risk
Realities of “Concerns” about In-house Software Development

- Requires too many people
- Too expensive
- We are not in that business
- Anything we might want someone has already written
- Anything we develop won’t be as good as what we can buy
- What if the person who wrote it leaves after a few years?
  - Well, you got a few good years out of it
  - If it fails the day they leave, it was probably too expensive to maintain anyway
  - Hire someone new to maintain it or re-write it
Advantages of In-house Software Development

• Can be custom designed for your needs/environment
  • Substantial workflow improvements

• Adaptable as needs change or become better defined

• Incrementally add on new functionality

• Enable new workflow/functions/roles not previously possible
Finding the Right People

• Significant workflow improvements can be achieved with just one developer
  • Issue of project scope and development time

• More than one allows specialized skill sets, division of labor, cross-coverage (less risk), team approach

• Productivity of software developers with comparable levels of experience can vary by a factor of ten!
  • Many people who market themselves as “programmers” are really super-users
  • Be sure to review examples of code they have written
  • Ultimately, performance in your environment will be key
    • Standard probation period may not be long enough to make that determination
Finding the Right People

• Factors affecting success
  • How much direction will they be given?
  • How much direction are they willing to take?
  • What development tools have they used in the past?
  • How well do they understand the domain?
  • How much do they expect the users to learn/adapt?
  • Are they self-learners or do they need instruction to learn?
  • How strong are their problem solving skills?
  • How well can they predict exceptions and accommodate them?
  • How intense is their attention to detail?
  • What is their level of pride in their product?
Finding the Right People

- **Yale Pathology’s Clinical Software Development Team**
  - **Informatics Director:** (~0.2 FTE clinical solution development time)
    - Pathologist
    - Workflow analysis, Specification development, LIS integration
  - **Associate Director of Informatics:** (~0.6 FTE clinical solution development time)
    - Non-pathologist physician; clinical informatics training
    - Business logic coding, deployment decisions
  - **Application Programmer:** (~0.8 FTE clinical solution development time)
    - No medical training; computer science major
    - User interface coding, user training, initial trouble-shooting
  - **TOTAL:** ~1.6 FTE (…transitioning in one more)

- Over 14 years, five other full time or part time developers failed to provide lasting synergy with the team

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In-House Clinical Software Development

- Digital Image File Management
- Scanned Document File Management
- Dictation/Transcription Management (built on Express Scribe)
- Outreach Support System (RELAY)
- Outreach Client Interface System
- Repetitive Task Scheduling Engine (automated, repetitive reporting tasks, rare event detection; built on Quartz Framework)
- Histology Asset Tracking
- Frozen Section Dx Mangmt & Communication to ORs (FSLink)
- “Hot Seat” Diagnosis Tracking/Evaluation system
- Altosoft Dashboard System Configuration/Integration
- Synoptic Diagnosis Reporting Tool
Custom Software Development Process

- **Functional Specifications**
  - Use cases, workflow analysis, environment integration

- **Technical Specifications**
  - Data storage, software architecture, scalability, maintenance

- **Software Development**
  - Tools, test environment, validation, documentation

- **Deployment**
  - Transfer to production, piloting, training, assessment

- **Updates and Enhancements**
  - Bug detection/correction, scope creep
Functional/Technical Specifications Development

• The MOST important on the software design process
  • Based on use cases
  • Look and feel: screen structure, functionality
  • Data structure and storage

• Design Considerations
  • Needs – what does it need to accomplish?
  • Workflow integration – how is it going to be used?
  • Environmental integration – where is it going to be used?
  • Personality constraints – who is going to be using it?
  • Maintainability – who is going to keep it running?
  • Scalability – will it hold up to increasing use and users?
Functional/Technical Specifications Development

• Could represent a single document or separate documents
  • One document is ideal, since functional compromises might be made by the technical implementation, and the impact of these needs to be assessed.

• May require expertise in multiple areas – team approach may be needed
  • Future uses provide use cases
  • Workflow analysis – defining tasks; process break-down
  • Solution design; user interfacing
  • Database modeling and design
  • Application structure and delivery
Custom Software Integration with LIS

• **Standalone Software**  (Database Interactions Only)
  • Scanned Document File Management
  • Outreach Support System & Outreach Client Interface System
  • Repetitive Task Scheduling Engine
  • “Hot Seat” Diagnosis Tracking/Evaluation system

• **Minimally Integrated**
  • Digital Image File Management
  • Dictation/Transcription Management
  • Frozen Section Management and Dx Communication to ORs (FSLink)

• **Deeply Integrated**
  • Histology Asset Tracking

• **Fully Integrated**
  • Synoptic Diagnosis Reporting Tool
Software Development

• Selection of development environment (IDE) and programming language

• Open Source Software
  • Self-selected groups of software developers who develop and improve a product and make it available for others to use, modify, and/or incorporate into their own solutions
  • May be made available as complied libraries or as documented source code
  • Often free; may carry restrictions for subsequent commercialization
  • Software development involves stitching together code components which has already been tested and debugged by multiple users
  • Examples: Linus OS, MySQL database, Apache Web Server, Apache Tomcat, Google Web Toolkit, Hibernate, Quartz, HAPI API (HL7 engine), iText, jFreeChart, etc.
Software Development

- Use of Open Source Software SUBSTANTIALLY mitigates the risks of custom software development
  - Marked decrease in development time / volume of code
  - Modules already well tested; supported by communities
- Rapid Application Development Model
  - “Release early, release often”
  - Users see rapid benefits to software development process
  - Allows adapting and fine-tuning specifications on the fly
- Test/Development Environment

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Software Development

• Validation (and the FDA)
  • Laboratory Information Systems are medical devices, but have been exempted from the 510(k) approval process since 1988
    • … except for blood-banking software, which is not exempt

• 2011: Medical Device Data Systems (MDDS)
  • Includes software which stores and/or displays data from medical devices
  • Reclassified from Class III to Class I
  • Developers required to register with the FDA
  • 21 CFR 807.65(d): “exempt from registration… licensed practitioners, including physicians, dentists, and optometrists, who manufacture or otherwise alter devices solely for use in their own practice”
Software Development

• Validation (and the FDA) - continued

• 2012: Laboratory Manual of Quality Policies
  • “5.4.7.2: Computer Use: When computers or automated equipment are used for the acquisition, processing, recording, reporting, storage, or retrieval of test data, … if computer software is developed by the user, its development is documented in detail and algorithms are validated”

• 2002: General Principles of Software Validation
  • Definition: “confirmation by examination and provision of objective evidence that software specifications conform to user needs and intended uses, and that the particular requirements implemented through software can be consistently fulfilled”
  • Acknowledges that the developer has to determine how much testing is “enough” and that one “cannot test forever”. Rather, the goal is to achieve “a level of confidence that the software meets all requirements and expectations”
Software Development

• Practical Software Validation
  • Extent of validation needed is highly dependent on what the software does
    • Creates new data vs simply display data already captures/created
  • Will it be immediately obvious to the user if the software is not functioning properly?
    • Users will not use software which does not do what it should do
  • Is there a risk that using the software could result in an inappropriate clinical action?
    • Greater risks require more extensive testing and documentation
Solution Deployment Considerations

- Staged or complete
- Time of day
- Synchronization of database and application changes
- Back-out plan
- On-site support after deployment
- Training
- Monitoring for unexpected behavior
Histology Asset (Block and Slide) Tracking

(Deeply Integrated into LIS)
Buy or Build Decision

- We evaluated the Tracking Solution available through our LIS vendor, and found it lacking
  - Designed on the model of a cassette labeler at each grossing station
  - Did not have enough constraints to assure patient safety
  - Assumed that if an asset was created, it was always used
  - Did not deal well with workflow exceptions (90:10 rule)
  - Used complex identifier in barcodes
  - Tracked assets, but did not drive the workflow
  - Very expensive
Histology Asset Tracking Software Features

- **Cassettes can be premade**
  - Identify case by scanning barcoded paperwork
  - Prevents duplicate cassettes (unless override)

- **Enter blocks into LIS by scanning**
  - Validation - Assures correct case (patient safety) and unique block number (workflow)
  - Only blocks actually used are tracked

- **Single piece workflow in histology**
  - Blocks can be embedded and cut in any order; no need for paper worklists
  - Scan block at microtome: prints labels for slides (“just in time” generation)
  - Slide numbers indicate level in block
  - Tentative slide numbers locked in by scanning to confirm successful cutting

- **Automatic ordering of slides for special situations**
  - Negative immuno controls, blocks to be reprocessed, extra sections

- **Slide reconciliation module identifies which cases are complete**

- **Dashboards monitor status of assets real-time**
  - Identify assets which have fallen behind
  - Generate real-time worklists
  - Adjust staffing assignments real-time based on work needs

- **Special Handling of unstained slides**
  - Can specify which level a stain ordered on an unstained slide is to be done

- **Quality assurance module for Special Stain and Immunohistochemistry**

- **Special handling of consults and other outside slides and blocks**
Monitoring Block Status

Ordered → Received → OnBatch → Embedded → Filed

Block Dashboard

<table>
<thead>
<tr>
<th>Ready for Pickup</th>
<th>Need to be Put on Processor Batch</th>
<th>Ready to Process</th>
<th>In processor</th>
<th>Need embedding</th>
<th>Need to be cut</th>
<th>Need to be filed</th>
</tr>
</thead>
</table>

- Processor batch not yet started
- Processor batch started; not marked finished
- Processor batch marked finished
- At least one slide for this block has a status of “Ordered”
- No slide for this block has a status of “Ordered”
List of blocks for Autopsy (Green) in In processor

<table>
<thead>
<tr>
<th>Block Number</th>
<th>Time Waiting (mins)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A10-00165 01-01</td>
<td>00d:13h:57m</td>
</tr>
<tr>
<td>A10-00165 01-02</td>
<td>00d:13h:57m</td>
</tr>
</tbody>
</table>

**A10-00165 01-06**

Current Status: **On Batch as of 09/07/10 06:21 PM**

**Block: 6 (of 11): 6 R KID/AD - [Not Entered] - Autopsy (Green)**

Acc: 09/03/10 12:00 AM
Request Class: Autopsy
YNHH Histology

Resident: Caleb Ho, M.D.
Attending: John H. Sinard, M.D., Ph.D.

<table>
<thead>
<tr>
<th>Date/Time</th>
<th>Status</th>
<th>Who</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>09/07/10 06:40 PM</td>
<td>Processor Start</td>
<td>JZ</td>
<td>Batch #: 28005</td>
</tr>
<tr>
<td>09/07/10 06:21 PM</td>
<td>On Batch</td>
<td>JZ</td>
<td>28005:6</td>
</tr>
<tr>
<td>09/07/10 06:21 PM</td>
<td>Received</td>
<td>JZ</td>
<td></td>
</tr>
<tr>
<td>09/07/10 04:51 PM</td>
<td>Ordered</td>
<td>CH</td>
<td></td>
</tr>
<tr>
<td>09/03/10 01:16 PM</td>
<td>Printed</td>
<td>[Not Entered]</td>
<td>Printed as Autopsy (Green)</td>
</tr>
</tbody>
</table>

Outside: - - - - - - -
Effect on Overtime in Histology

[Graph showing OT $$ and Blocks over time with a Tracking System annotation]
Frozen Section Management and Communication

FSLink

(Minimally Integrated into LIS)
The Need

- Increasing frequency of frozen sections in general (more ORs) and of simultaneous frozen sections in particular
- Need for ready access to prior information on patients
- Time to phone in diagnoses takes time away from evaluating next FS (?phone number, read backs, etc)
- Concern by some surgeons – acting on a “verbal” diagnosis
- Legibility of FS diagnoses “hastily recorded”
- Accurate recording of FS diagnoses and staff in LIS
- Billing for frozen sections frequently overlooked
  - Either not recorded on working draft, or not entered by transcriptionist, or not checked by pathologist at electronic sign-out
- Poor tracking of turnaround statistics; manual calculations

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Frozen Section Management Solution

• “Buy it” vs “Build it”
  • No one sells it
  • Opportunity for integration into existing LIS

• Process
  • Manage expectations of chairs with respect to development time
  • Designed by a pathologist who does time on the frozen section service
  • Got surgery to assign a “contact person” to sign-off on the design
  • Tested by designer when he was on service
  • Demonstrated to hospital IT to get buy-in and support for OR deployment
  • Demonstrated to Pathology attendings
  • Deployed in 3 stages: Pathology module, CoPath integration, OR module
  • Had 2 meetings with OR nursing/support staff to educate
Design Considerations - Practical

• Has to be easy to use
  • Automatic login from standard workstations based on IP address
  • Intuitive interface
  • Visual cues when actions are needed

• Pathology completely controls what can be seen in ORs

• Value added features
  • Dynamic list of active cases
  • Ready access to surgeon’s name and OR phone number information
  • Access to prior diagnoses on patient
  • Real-time turnaround-time information
  • Facilitated entry of diagnoses; automated entry of staff and fee codes
  • New capabilities – image sharing, report generation

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FSLink – LIS Data Processing

- *The next time the case is accessed in CoPath:*
  - The frozen section diagnosis field is built from the information in FSLink
    - No longer necessary to dictate the frozen section diagnoses
    - No longer necessary for transcriptionists to type frozen section diagnoses
    - No possibility of misreading or mistyping
  - The frozen section staff (pathologist and resident) are entered
  - The # blocks and # touch preps information is used to automatically insert the correct fee codes
Frozen Section Billing Errors

- Error with 88331 or 88332
- Deploy CoPath Integration
- Error with 88333 or 88334
- Modify working draft
- Error with 88329
Frozen Section Under-billing

Professional Charges

Technical Charges

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Digital Image File Management

*(Minimally Integrated into LIS)*
Digital Image Acquisition and Storage

- We have CoPath
  - Runs under Windows, but we have all Macs; deliver application using Citrix
  - PICSPlus module requires camera to be “attached” to computer running CoPath
  - We already had some digital cameras, none of which were “approved” by Cerner for use with CoPath
- Wanted to use images for patient reports, but also for teaching, presentations, etc.
- Needed a generic image management system which would assure images were filed correctly all the time
Yale Pathology Clinical Imaging

Ad hoc Images

Manual Naming

Gross Image Capture

Photomicrographs

Custom Image Uploading Program

Image Drop Folder

Image Filing Engine

Image Repository

Intranet Access

Step 1

Step 2

Lab Info System

Images in Reports

Database

Image Files
Scanned Document File Management

(Standalone Software – Only database reads from LIS)
Requisition Handling Issues

- Sometimes contain useful clinical information
- Desirable to have available at time of signout
- Frequent sorting
  - Primary copy sorted to allow collating with working drafts
  - Gross room copy sorted for filing
  - Billing copy transferred to Accounting service for Registration
  - Sorted after signout for filing
  - Removed from working drafts and sent for microfilming
- Need to be retained for minimum of 2 years
Requisition Handling Costs

- With >90,000 cytology specimens and >45,000 surgical specimens per year, represents about 150,000 unique documents, most of which are copied at least once to support our workflow.

- Department was spending $15-25K per year for microfilming or contracted digital archiving services.

- The major cost is man-hours spent sorting, copying, collating with working drafts, distributing, resorting, removing from working drafts, removing staples, resorting, sending for microfilming.
  - Minimum of 5-10 hrs / day department-wide, or approximately 1 FTE.
  - Does NOT include time spent looking for/retrieving documents.
Requisitions Available via Existing Web Interface

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Repetitive Task Scheduling Engine (RTSE)

(Standalone Software – Only database reads from LIS)
Repetitive Tasks

• Image filing and document filing were just two of the many things which, ideally, need to be done multiple times a day - not practical to trigger this manually

• There are many other tasks which need to be done regularly, at least daily
  • Check the nightly backup
  • Check that the billing batches were sent
  • Distribute overdue case lists

• There are a variety of “rare” events which it would be nice to look for on a regular basis
  • Is the web site still up?
  • Are the web-applications still running?
Repetitive Task Scheduling Engine (RTSE)

- We don’t have the staff to keep up on all the daily tasks
- Decided to generalize our repetitive task management
- Solution based on the open source Quartz scheduling engine from OpenSymphony
- Each task is based on a Job Type, represented by a Java Class, which enables the functionality of that job type
- Each task instance is associated with one or more time triggers, which determine when the task is executed
- Each task instance produces one or more “actions” based on the result of the task
Repetitive Task Scheduling Engine

- Define Job Instances
- Add Jobs to Scheduler
- Actions

Trigger(s)
Action(s)
Job/Task
Scheduling Engine
Page
eMail
Scheduled Tasks

Currently have over 40 jobs running with frequencies between every 20 seconds and monthly. Never takes a day off…. Never complains….

- **Filing / Routing Jobs (every 20 seconds)**
  - Images
  - Requisitions
  - Dictations

- **Overdue/Active Case Lists**
  - Each weekday morning, each attending is emailed list of cases > 6 days old
  - Each Monday morning, each attending is emailed list of active autopsy cases

- **Reports to Move Workflow**
  - Gross only cases ready to be signed out
  - Alerts to retrieve removed medical devices which need to be returned
  - Prioritized duplicate patient identification (specimens on “both” patients)
Scheduled Tasks

(Continued)

• QA and other Monitoring Reports
  • Frozen Section / Final Diagnosis Comparison reports
  • Break-glass audits for Outreach Support System
  • Abnormal PAP smear or HPV results reports by Client – sent to clients
  • Block / Slide QA reports to Histology Manager

• HL7 Client Interface Tasks
  • Identify reports ready for distribution to outreach clients; provide on-demand
  • Process “ADT” messages from Clients to RELAY and RELAY to CoPath

• User Notification Tasks
  • Notify users of pending password expirations
  • eMail Neuropathologists whenever an autopsy is accessioned
  • Page/eMail Neuropathologists when a neuropath surgical case is received
Scheduled Tasks

(Continued)

- **Rare Event Detection**
  - **Hardware Failures**
    - Checks all servers every five minutes; page ITS on exception
    - Checks video servers; page ITS on exception
  - **Software Failures**
    - eMail / Page on Billing Batch Failure
    - eMail / Page on Backup failure or errors
    - Verify RELAY is running and accepting log-ons; page on exception
- **Data Consistency Checks**
  - Non-autopsy case accessioned to a deceased patient
  - Amendment / addenda on a case with an inactive client report chute
  - Physician/Client mismatch
  - Morgue patients without: date of death; appropriate encounter status
- **Utility Jobs**
  - Dictionary synchronization
  - PDF report collection
Improved Efficiencies Yielded from RTSE

- Automated, controlled routing of files
  - Includes file renaming, validity checking, processing of errors

- Regular monitoring of events which “should be checked regularly”
  - No concern about forgetting, monitor-er out sick, etc

- More timely notification of failures - more rapid response

- Detection of rare events

- Support staff can spend time fixing problems rather than looking for them
“Hot-Seat” Application / Pathology Portal

(Standalone Software – Only database reads from LIS)
The “Hot Seat” Rotation

- **Surgical Pathology Rotation – Senior Resident/Fellow**

- Reviews “all” slides coming out of histology
  - Makes and records provisional diagnoses
  - Fields phone calls / visits from clinicians
  - Re-directs cases to appropriate subspecialty service
  - Initiates workup of cases requiring recuts/immunostains

- “Oversees” smooth running of Surgical Pathology
Operational Difficulties with the “Hot Seat” Rotation

• Easy access to necessary information about the case
  • Status of slides; prior material; clinical history; photographs

• Easy access to clinician contact information

• Easy mechanism to record / retrieve impressions
  • vs Logbook

• FEEDBACK
  • How was the case eventually signed out?

• Performance tracking
| Specimen: | 511-24910 |
Clinical History: Patient with history of ulcerative colitis 40 years ago-asymptomatic for 35 years. In past years, several surveillance biopsies have always been normal. Polyp right colon. (See S00-8547 and S97-...)

1) APPENDICEAL ORIFICE POLYP BIOPSY (1 blk) (1 slide)
2) PROXIMAL COLON RANDOM (1 blk) (1 slide)
3) DISTAL COLON BIOPSY (1 blk) (1 slide)
Surgical Pathology Report

Patient: LASTNAME, FIRSTNAME
MR #: 1234567
DOB/Age/Sec: 01/01/1949 (Age: 50) F
Client: Temple Endoscopy Ctr
Submitting Physician: Suzanne P. Lagarde, M.D.

Accession #: S00-8547
Taken: 4/5/2000
Reported: 4/7/2000 00:49

Clinical History and Impression:
50 year old white female history of severe colitis more than 20 years but asymptomatic for years, on steroids.

Specimen(s) Received:
1) TERMINAL ILEUM
2) RIGHT COLON
3) TRANSVERSE COLON
4) DESCENDING COLON
5) SIGMOID COLON
6) RECTUM

Final Diagnosis

1) TERMINAL ILEUM, BIOPSY:
   - ILEAL MUCOSA, WITHOUT SIGNIFICANT ABNORMALITY

2) COLON, RIGHT, BIOPSY:
   - COLONIC MUCOSA, WITHOUT SIGNIFICANT ABNORMALITY
   - NO EVIDENCE OF DYSPLASIA

3) COLON, TRANSVERSE, BIOPSY:
   - COLONIC MUCOSA, WITHOUT SIGNIFICANT ABNORMALITY
   - NO EVIDENCE OF DYSPLASIA

4) COLON, DESCENDING, BIOPSY:
   - COLONIC MUCOSA, WITHOUT SIGNIFICANT ABNORMALITY
   - NO EVIDENCE OF DYSPLASIA
**CASE NOT YET SIGNED OUT**
### Clinical History
Patient with history of ulcerative colitis 40 years ago-asymptomatic for 35 years. In past years, several surveillance biopsies have always been normal. Polyp right side.

### Score Level of Agreement
- **Agree:** 0 (0%)
- **Mostly Agree:** 0 (0%)
- **Disagree:** 0 (0%)

**Note:** Whether the adenomatous polyp seen at the appendiceal orifice represents sporadic adenoma or is a result of ulcerative colitis cannot be determined by the histological appearance alone. Complete removal of the polyp is suggested if this has not already been accomplished. Random surveillance biopsies are negative for colitis and dysplasia.
## Summary Statistics

<table>
<thead>
<tr>
<th>Service</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Disagree</th>
<th>Exclude</th>
<th>Not Scored</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone/Soft Tissue</td>
<td>33 (84%)</td>
<td>4 (10%)</td>
<td>2 (5%)</td>
<td>1</td>
<td></td>
<td>40</td>
</tr>
<tr>
<td>Breast</td>
<td>111 (76%)</td>
<td>17 (11%)</td>
<td>18 (12%)</td>
<td>3</td>
<td></td>
<td>149</td>
</tr>
<tr>
<td>Bridgeport</td>
<td>3 (100%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Dermpath</td>
<td>32 (60%)</td>
<td>4 (7%)</td>
<td>17 (32%)</td>
<td>2</td>
<td></td>
<td>55</td>
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<tr>
<td>Eye</td>
<td>18 (69%)</td>
<td>3 (11%)</td>
<td>5 (19%)</td>
<td></td>
<td></td>
<td>26</td>
</tr>
<tr>
<td>Gastrointestinal</td>
<td>143 (70%)</td>
<td>33 (16%)</td>
<td>28 (13%)</td>
<td>5</td>
<td></td>
<td>209</td>
</tr>
<tr>
<td>Gynecology</td>
<td>157 (80%)</td>
<td>18 (9%)</td>
<td>20 (10%)</td>
<td>3</td>
<td></td>
<td>198</td>
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<tr>
<td>Head/Neck/Endocrine</td>
<td>70 (79%)</td>
<td>3 (3%)</td>
<td>15 (17%)</td>
<td>3</td>
<td></td>
<td>91</td>
</tr>
<tr>
<td>Heme</td>
<td>32 (78%)</td>
<td>2 (4%)</td>
<td>7 (17%)</td>
<td>8</td>
<td></td>
<td>49</td>
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<tr>
<td>Neuro</td>
<td>17 (80%)</td>
<td>3 (14%)</td>
<td>1 (4%)</td>
<td>2</td>
<td></td>
<td>23</td>
</tr>
<tr>
<td>Renal/EM/Heart</td>
<td>2 (100%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Thoracic/Gu/Misc</td>
<td>80 (74%)</td>
<td>10 (9%)</td>
<td>17 (15%)</td>
<td></td>
<td></td>
<td>107</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>698 (75%)</td>
<td>97 (10%)</td>
<td>130 (14%)</td>
<td>28</td>
<td></td>
<td>953</td>
</tr>
</tbody>
</table>
Hot Seat Application

- Application has significantly improved residents’ reviews of the Hot Seat rotation
- Residents are reviewing more cases than before
- Satisfies ACGME requirement for “Practice-based Learning and Improvement”
- Application has been used outside of the rotation by attendings who want to quickly access information about a case/patient
- Redesign to deliver pathology reports to other “users” without sacrificing licensed seats
Take Home Messages

- Operational improvements can be obtained through the use of customized informatics tools.
- Those tools do not all have to be integrated into the Laboratory Information System.
- Where possible, custom tools should be designed philosophically to move the work forward rather than simply keeping track of what work was already done.
- Investments in “customized” solutions can be incrementally expanded to address other problems.