LEARNING ANALYTICS AND MEDICAL IMAGING

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OBJECTIVES

<u>Exploratory Analysis</u>: Understand the relationships between measures of learner engagement and learner achievement in historical MED-U databases using results from focus group discussions

LEARNING ANALYTICS

…is an emerging field in which analytic tools adapted from computer science, math, and statistics are used to improve learning and education by extracting usable information from very large datasets.

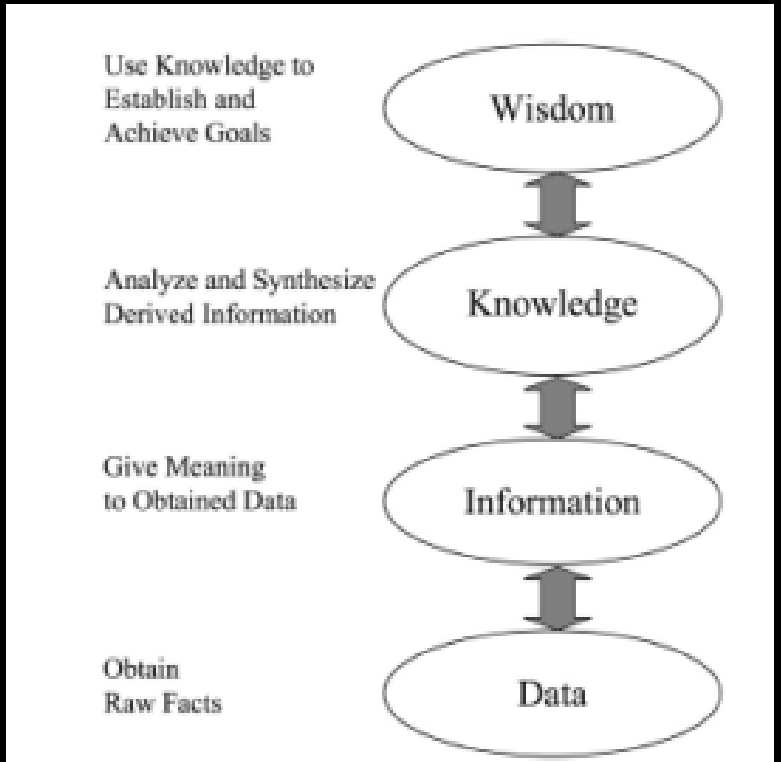

Figure 1: Baker's (2007) depiction of the Knowledge Continuum.

SOURCE: Elias, T. 2011. *Learning Analytics: Definitions, Processes and Potential*.

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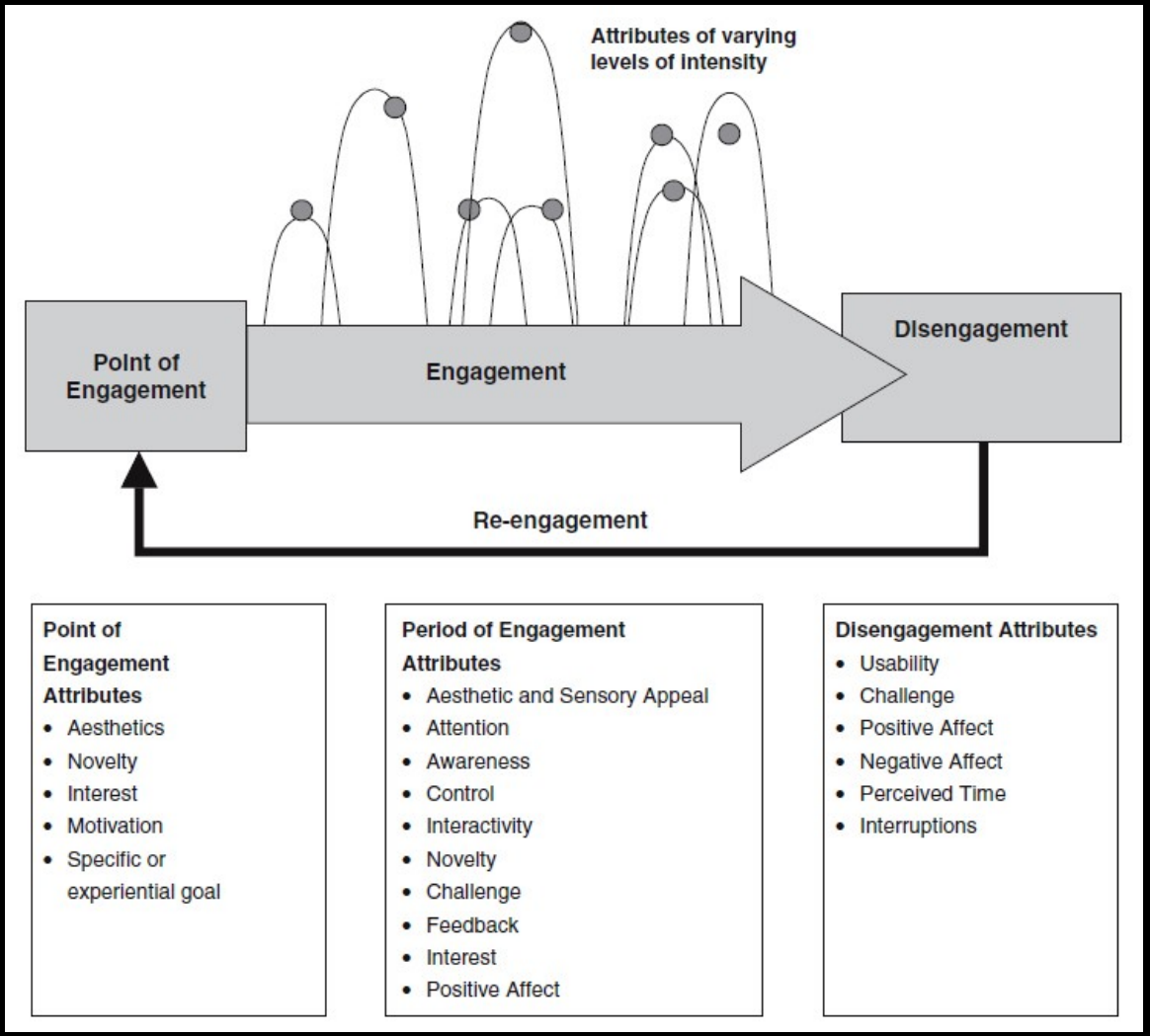
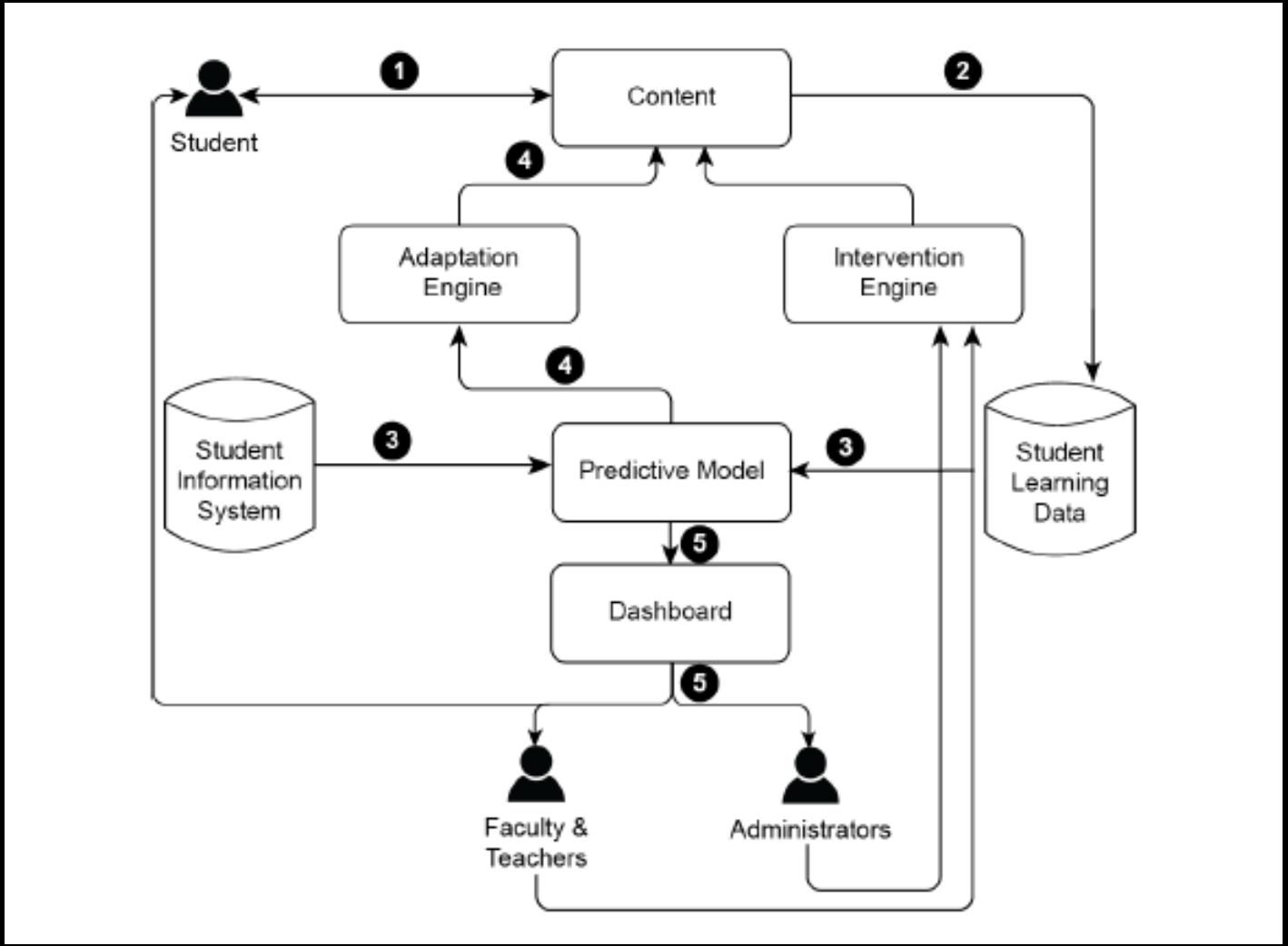
CONCEPTUAL MODEL FOR ENGAGEMENT



SOURCE: O'Brien, H. L., & Toms, E. G. (2008). What is user engagement? A conceptual framework for defining user engagement with technology. *Journal of the American Society for Information Science and Technology*, *59*(6), 938-955.

ADAPTIVE LEARNING SYSTEM: COMPONENTS AND DATA FLOW

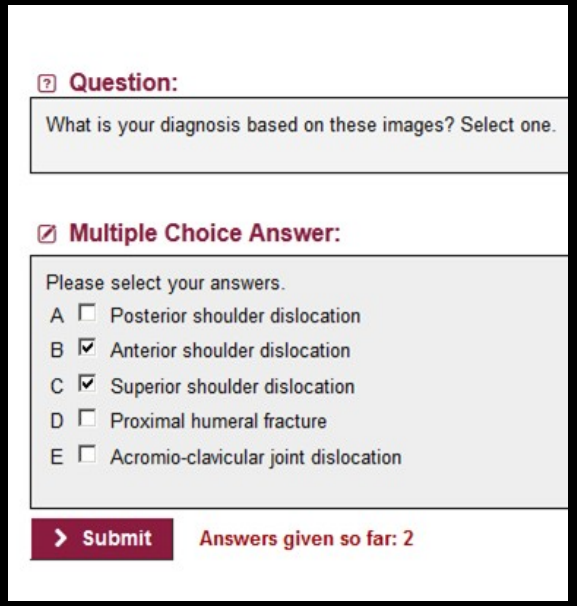


SOURCE: Elias, T. (2011). Learning analytics: Definitions, processes and potential. Learning, 23, 134-148.

CLICK-LEVEL DATA

- Multiple choice questions
- Image comprehension items
- Hyperlinks
- Page progression clicks
- Enlarging images
- Checking answers
- Time spent on images, pages, etc.
- How many times a video is paused, on which frames, and if a video is replayed, etc.

A RELEVANT ASSESSMENT



Content
(Images, links, etc.)

Relevant Multiple Choice Question

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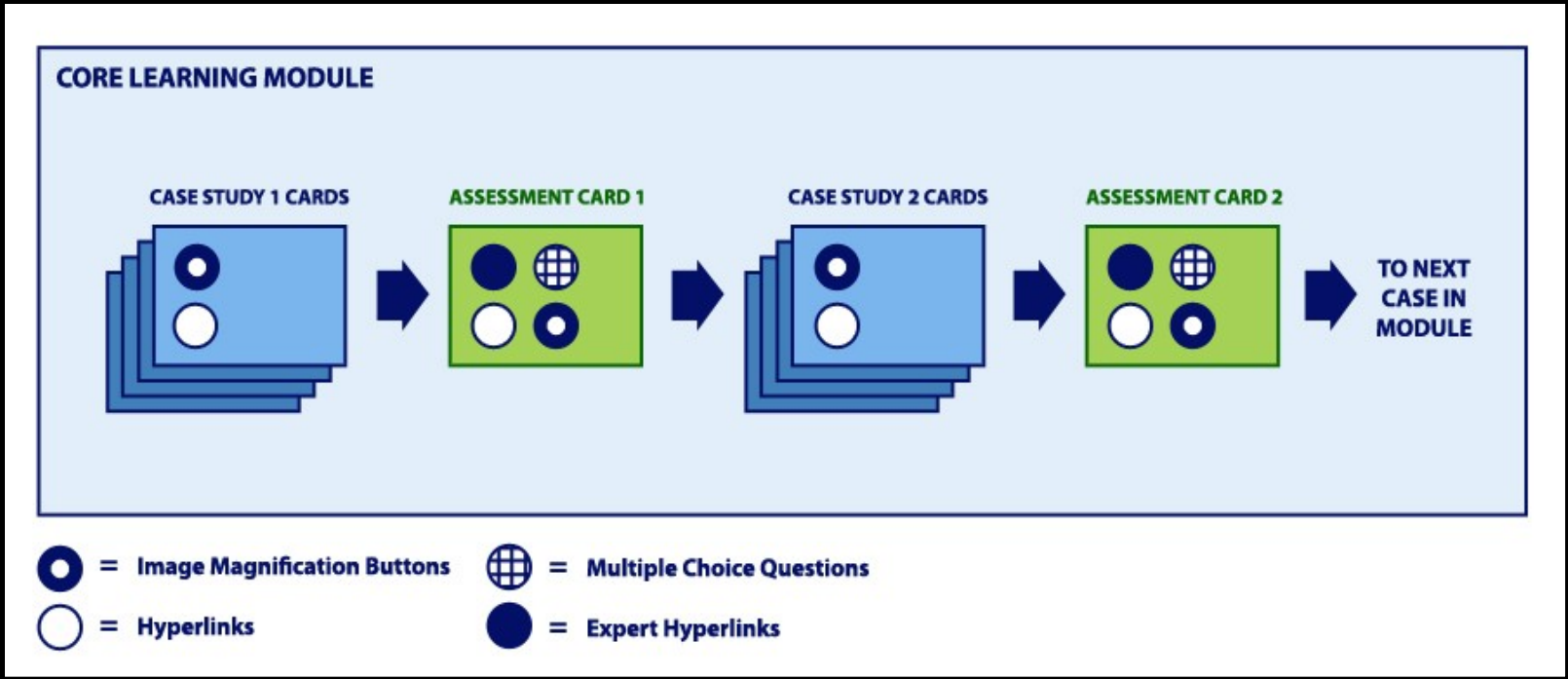
MODULE PROGRESSION



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Mrs. Potter does well during the procedure and is transferred to the orthopedic floor.

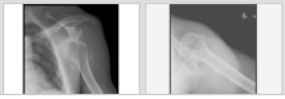
Your next patient is Mr. O'Neil, a 21-year-old snowboarder complaining of left shoulder pain after a fall.

On exam his pupils are dilated and he smells of marijuana. You have him remove his shirt. His shoulder demonstrates a "squared off" appearance with skin depression over the deltoid muscle contour. He is unable to raise his arm. The patient is sent for radiographs.

Want to see a labeled normal shoulder series before you look at his images?

Go to the University of Washington's musculoskeletal radiology site.

AP view of the shoulder



Question:

What is your diagnosis based on these images? Select one.

Multiple Choice Answer:

A	✖	☑	Posterior shoulder dislocation
B	✔	☑	**Anterior shoulder dislocation**
C	✖	☑	Superior shoulder dislocation
D	✔	☐	Proximal humeral fracture
E	✔	☐	Acromio-clavicular joint dislocation

Please note: ✔ ✖ show whether YOUR choice is correct or not, to toggle highlight what the expert selected, **please click here!**

B has been selected by the expert.

This is an **anterior shoulder dislocation (B).** The AP view shows the humeral head resting anterior to the glenoid fossa in a subcoricoid location. The axillary view confirms the anterior trajectory of the dislocation as the humeral head rests anterior to the glenoid.

The axillary view anatomy can be difficult to identify, so it helps if you know how it is obtained. See the Expert for more details of the views obtained on shoulder radiographs.

Navigation

Tools/Resources

My notes

No notes taken so far

Expert

PHASE 1

FOCUS GROUP RESULTS

Six experts grouped and ordered candidate analytic measures (CAMs), revealing which were considered the most useful:

(1) Thumbnail Click
(2) Post-Answer Feedback Use
(3) Supplementary Link Click
(4) Zooming-in on Images
(5) Duration on Images and Cases

Ranking of Candidate Learning Analytics Measures (CAMs)

	Candidate Learning Analytic Measures					
	1	2	3	4	5	6
	Thumbnail Click	Supplementary Link Click	Duration on Cases/Images	Zooming-in on Images	Post-answer Feedback Use	Proportion of Feedback Used
Expert 1	1	12	8	2	5	11
Expert 2	1	2	8	5	3	4
Expert 3	1	2	1	2	1	1
Expert 4	4	2	6	5	3	1
Expert 5	2	2	5	2	4	4
Expert 6	4	4	4	8	1	8
TOTAL	**13**	**24**	**32**	**24**	**17**	**29**
Std. Dev.	**1.5**	**4.0**	**2.7**	**2.4**	**1.6**	**4.0**

	Candidate Learning Analytic Measures					
	7	8	9	10	11	12
	Labeled Peer Answers	Viewing Sequence I	Relative Time on Views	Video Playback Speed	Opposing Design Choices	Forced Views
Expert 1	6	4	10	9	3	7
Expert 2	9	6	7	5.8	6.4	6
Expert 3	3	3	3	3	3	1
Expert 4	7	8	9	10	11	12
Expert 5	1	3	5	6	7	2
Expert 6	1	4	8	1	8	8
TOTAL	**27**	**28**	**42**	**35**	**38**	**36**
Std. Dev.	**3.3**	**2.0**	**2.6**	**3.4**	**3.1**	**4.0**

COMMENTS SUPPORTING CAM-A

Expert Quote #1: *"Learning analytics should show us if learning has occurred or not. [Thumbnail click], [supplementary link click], [zooming on images], and [forced views], they are that kind of variable…"*

Expert Quote #2: *"I would start with the most active learner. Who made use of all the available stuff…"*

Expert Quote #3: *"…where I'm seeing this as helpful is, as a course director, where do I need to add content…"*

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COMMENTS SUPPORTING CAM-B

Expert Quote #1: *"…[post-answer feedback] made my top three [learning analytics]…"*

Expert Quote #2: *"As a course director, [labeled peer answers], [post-answer feedback use], and [video playback speed] are good for me…look at data for the bottom five percent."*

Expert Quote #3: *"I would start with the most active learner. Who made use of all the available stuff…"*

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COMMENTS SUPPORTING CAM-C

Expert Quote #1: *"Learning analytics should show us if learning has occurred or not. [Thumbnail click], [supplementary link click], [zooming on images], and [forced views], they are kind of variable…"*

Expert Quote #2: *"Some modules use the same links, so students might not click on the links because they recognize it from a previous module."*

Expert Quote #3: *"I would start with the most active learner. Who made use of all the available stuff…"*

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COMMENTS SUPPORTING CAM-D

Expert Quote #1: *"Learning analytics should show us if learning has occurred or not. [Thumbnail click], [supplementary link click], [zooming on images], and [forced views], they are kind of variable…"*

Expert Quote #2: *"Some modules use the same links, so students might not click on the links because they recognize it from a previous module."*

Expert Quote #3: *"I would start with the most active learner. Who made use of all the available stuff…"*

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COMMENTS SUPPORTING CAM-E

Expert Quote #1: *"Some students on average spend 15-20 minutes on an individual module…"*

Expert Quote #2: *"You can't go through 20 slides in 20 seconds…"*

Expert Quote #3: *"If the student is doing well, all [the module does is] alert you to the fact that she was moving through this rapidly, but had her own mechanism of learning."*

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CAM-A: THUMBNAIL CLICK

(Card 13, MSK Trauma)

(Card 15, MSK Trauma)

Question:

What abnormalities do you see? Select one or more.

Multiple Choice Answer:

A	✔	☐	Tibial plateau fracture
B	✔	☑	Knee joint effusion
C	✖	☐	Lateral tibia avulsion fracture
D	✖	☑	Patellar fracture
E	✔	☐	Proximal fibular fracture

In an image set where there is one dominant image along with several supplementary clickable thumbnails, does the rate of clicking through the thumbnails correlate with learning?

What we need is:

(a) Whether users clicked each thumbnail, yes/no

(b) Whether they got the relevant MCQ correct

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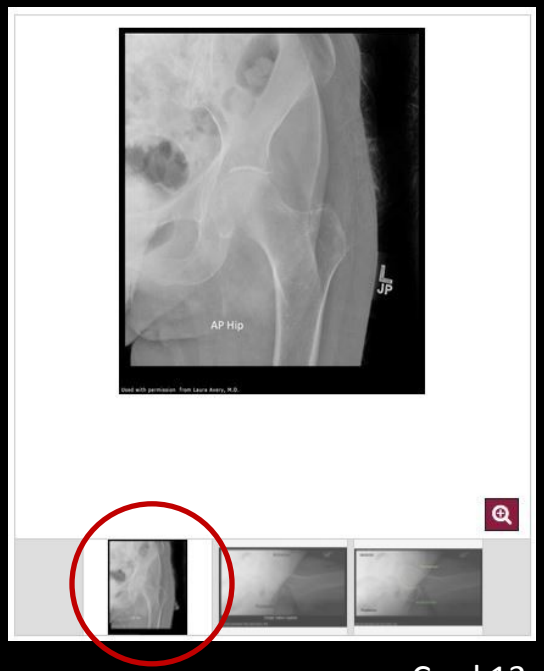
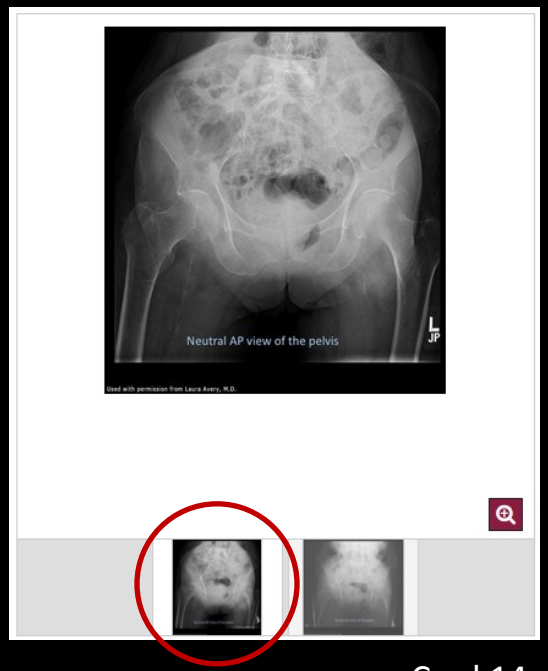
EXAMPLES OF CAM-A

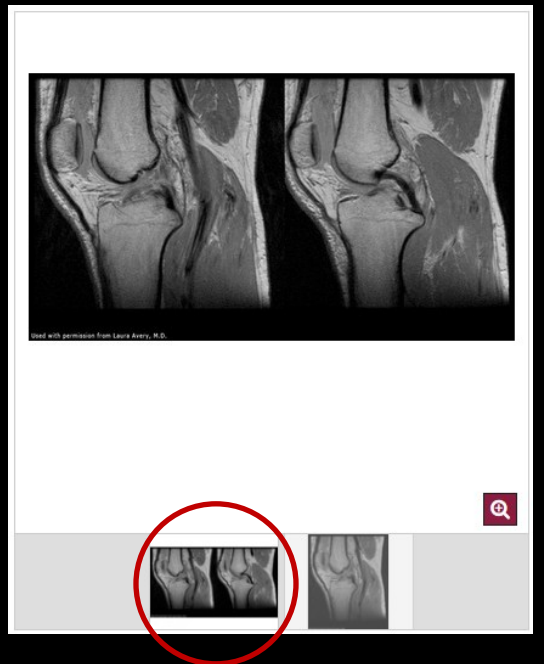
CORE Lesson 16. MSK: Trauma, cards 13-15 have image galleries with multiple thumbnails. Comparing learning with the click rate on these images can help us understand if this learning measure is helpful.



Card 13



Card 14



Card 15

* Click data needed for all of the thumbnails, not just those circled here.

EXAMPLES OF CAM-A

CORE Lesson 16. MSK: Trauma, card 15 has a multiple choice question that is relevant to image galleries on cards 13-15.

Question:

Which of the following would be appropriate next tests to perform in this patient? Select one or more.

Multiple Choice Answer:

Author defined that display of expert answer is disabled on this card.

A	62.4%	☐	CT scan of the pelvis and proximal femurs
B	34.5%	☑	MR scan of the pelvis and proximal femurs
C	10.4%	☑	Radionuclide bone scan
D	24.8%	☑	Frogleg views of the hips
E	21.7%	☐	Repeat radiographs in 7-10 days

(Card 15, MSK Trauma)

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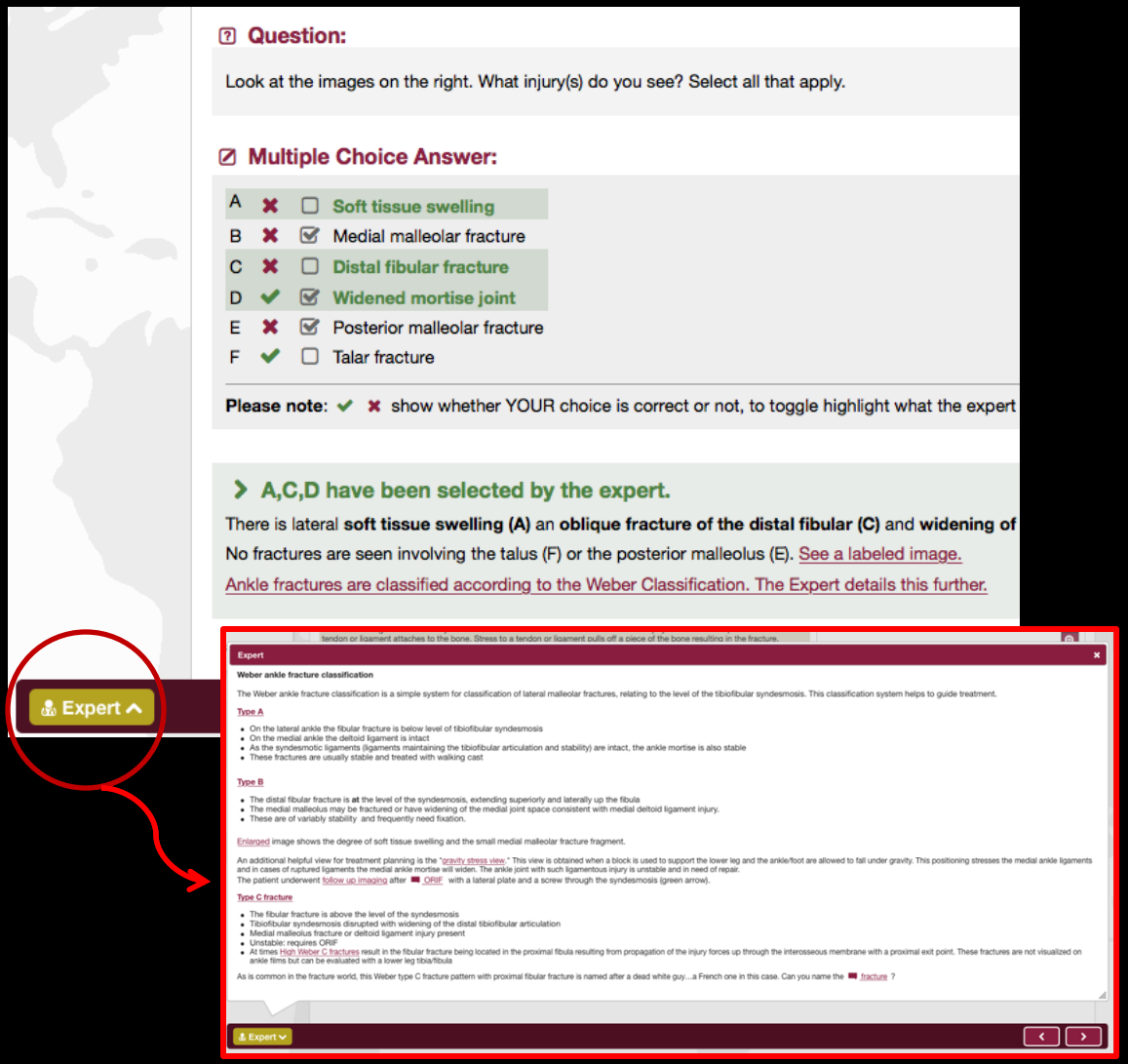
CAM-B: POST-ANSWER FEEDBACK USE



(Card 5, MSK Trauma)

Does learning correlate with how often a user clicks on links in the expert window?

What we need is:

(a) Whether users clicked links in the expert window

(b) Whether they got the relevant MCQs correct

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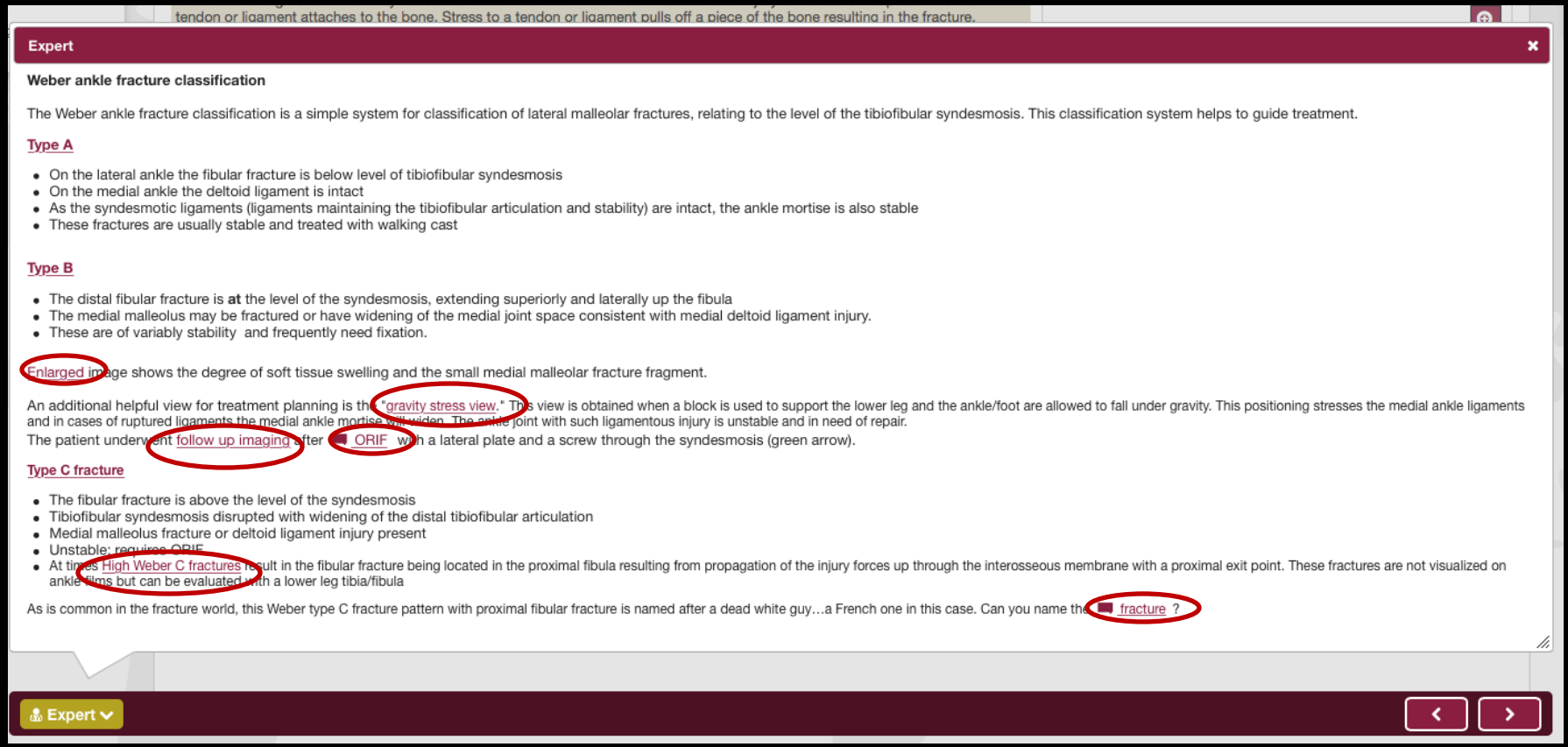
EXAMPLES OF CAM-B

CORE Lesson 16. MSK: Trauma, card 5 has links that appear after clicking a yellow "EXPERT" button once answers are submitted. Comparing learning with the click rate on these can help us understand if this learning measure is helpful.



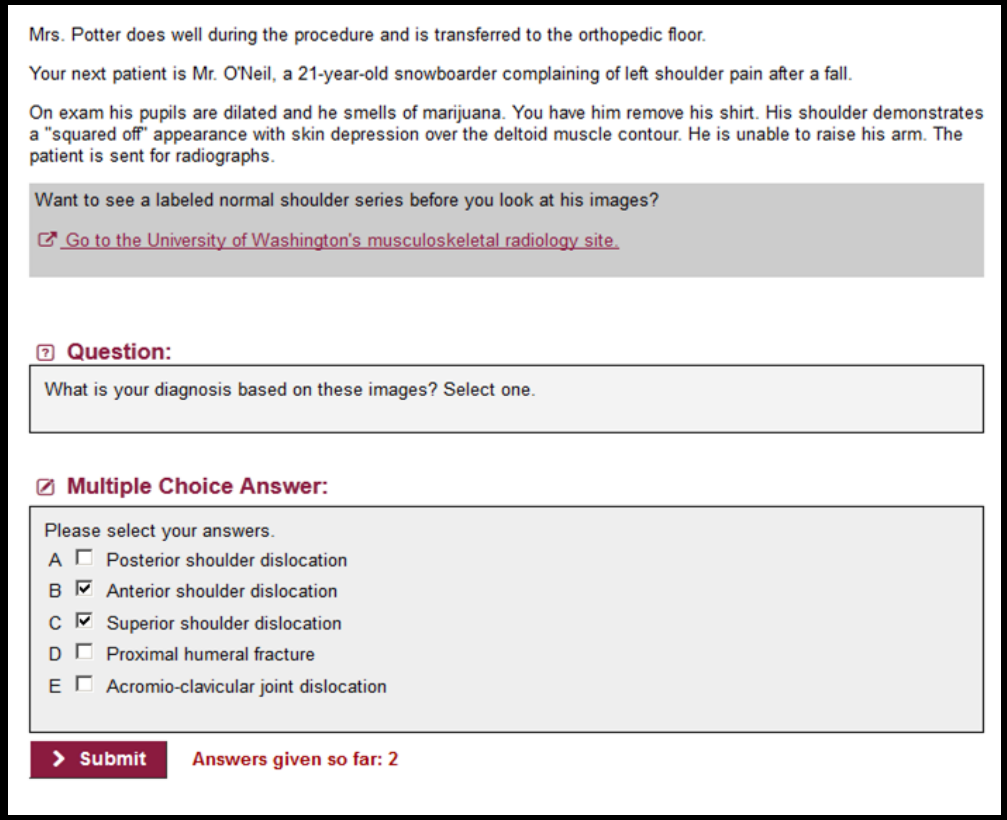
CAM-C: SUPPLEMENTARY LINK CLICK

In the presence of supplementary links to external content, does the rate of clicking through the links correlate with learning?

What we need is:

(a) Whether users clicked links

(b) Whether they got the relevant MCQ correct



(Card 15, MSK Trauma)

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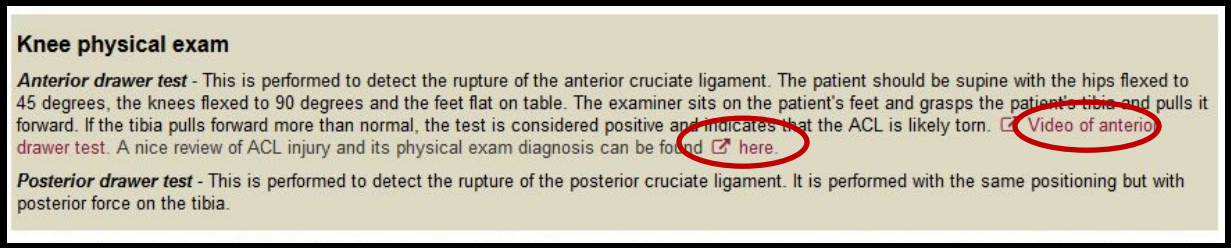
EXAMPLES OF CAM-C

CORE Lesson 16. MSK: Trauma, card 8 has links that appear before an answer is submitted. Comparing learning with the click rate on these links can help us understand if this learning measure is helpful.

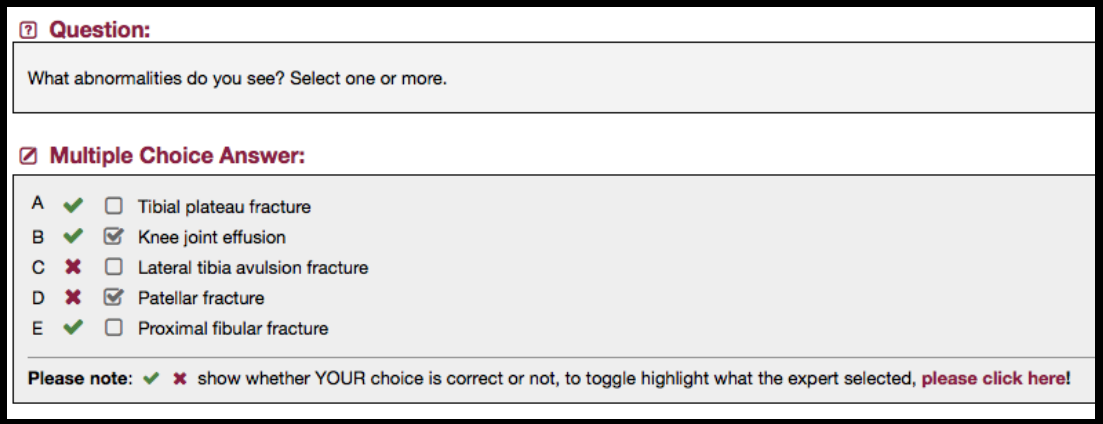


Knee physical exam

Anterior drawer test - This is performed to detect the rupture of the anterior cruciate ligament. The patient should be supine with the hips flexed to 45 degrees, the knees flexed to 90 degrees and the feet flat on table. The examiner sits on the patient's feet and grasps the patient's tibia and pulls it forward. If the tibia pulls forward more than normal, the test is considered positive and indicates that the ACL is likely torn. Video of anterior drawer test. A nice review of ACL injury and its physical exam diagnosis can be found here.

Posterior drawer test - This is performed to detect the rupture of the posterior cruciate ligament. It is performed with the same positioning but with posterior force on the tibia.

Card 8



Question:

What abnormalities do you see? Select one or more.

Multiple Choice Answer:

A	✔	☐	Tibial plateau fracture
B	✔	☑	Knee joint effusion
C	✖	☐	Lateral tibia avulsion fracture
D	✖	☑	Patellar fracture
E	✔	☐	Proximal fibular fracture

Please note: ✔ ✖ show whether YOUR choice is correct or not, to toggle highlight what the expert selected, **please click here!**

Card 9 (Relevant MCQ)

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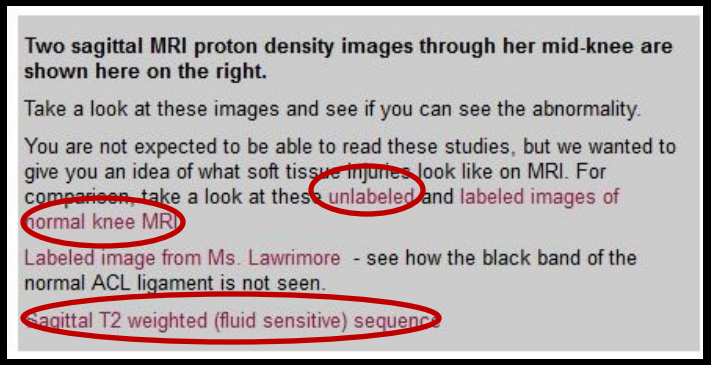
EXAMPLES OF CAM-C

CORE Lesson 16. MSK: Trauma, card 13 has links that appear before an answer is submitted. Comparing learning with the click rate on these links can help us understand if this learning measure is helpful.



Two sagittal MRI proton density images through her mid-knee are shown here on the right.

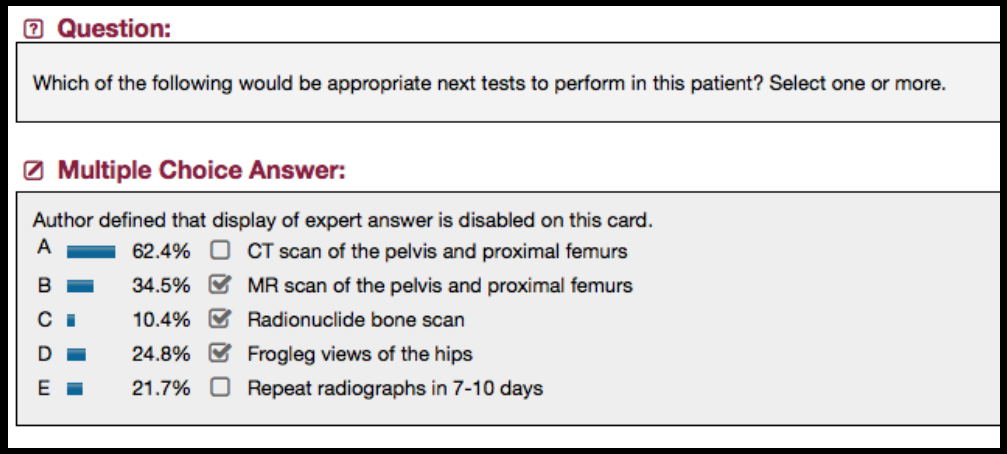
Take a look at these images and see if you can see the abnormality.

You are not expected to be able to read these studies, but we wanted to give you an idea of what soft tissue injuries look like on MRI. For comparison, take a look at these unlabeled and labeled images of normal knee MRI.

Labeled image from Ms. Lawrimore - see how the black band of the normal ACL ligament is not seen.

Sagittal T2 weighted (fluid sensitive) sequence

Card 13



Question:

Which of the following would be appropriate next tests to perform in this patient? Select one or more.

Multiple Choice Answer:

Author defined that display of expert answer is disabled on this card.

A	62.4%	☐	CT scan of the pelvis and proximal femurs
B	34.5%	☑	MR scan of the pelvis and proximal femurs
C	10.4%	☑	Radionuclide bone scan
D	24.8%	☑	Frogleg views of the hips
E	21.7%	☐	Repeat radiographs in 7-10 days

Card 15 (Relevant MCQ)

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CAM-D: ZOOMING-IN ON IMAGES

Does the rate at which one zooms in on an image or images correlate with learning?

Our hypothesis might be that those who zoomed in on the images had a higher rate of correct answers on relevant MQCs…

What we need is:

(a) Whether users clicked zoom button

(b) Whether they got the relevant MCQ correct

Question:

Look at the images on the right. What injury(s) do you see? Select all that apply.

Multiple Choice Answer:

A	✗	☐	Soft tissue swelling
B	✗	☑	Medial malleolar fracture
C	✗	☐	Distal fibular fracture
D	✓	☑	Widened mortise joint
E	✗	☑	Posterior malleolar fracture
F	✓	☐	Talar fracture

Please note: ✓ ✗ show whether YOUR choice is correct or not, to toggle highlight what the expert selected, **please click here!**

AP, mortise view, lateral view

(Card 5, MSK Trauma)

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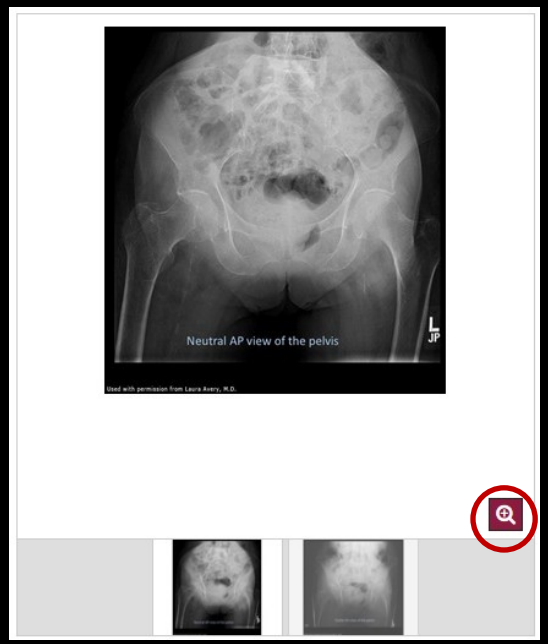
EXAMPLES OF CAM-D

CORE Lesson 16. MSK: Trauma, cards 13-15 have image galleries with zoom buttons. Comparing learning with the click rate on these can help us understand if this learning measure is helpful.

Card 13



Card 14

Card 15

EXAMPLES OF CAM-D

CORE Lesson 16. MSK: Trauma, card 15 has a multiple choice question that is relevant to image galleries on cards 13-15.

Question:

Which of the following would be appropriate next tests to perform in this patient? Select one or more.

Multiple Choice Answer:

Author defined that display of expert answer is disabled on this card.

A	62.4%	☐	CT scan of the pelvis and proximal femurs
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C	10.4%	☑	Radionuclide bone scan
D	24.8%	☑	Frogleg views of the hips
E	21.7%	☐	Repeat radiographs in 7-10 days

(Card 15, MSK Trauma)

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CAM-E: TIME DURATION

Does the length of time on an image or case correlate with learning?

Our hypothesis might be that those who spent more time on images/cases have a higher rate of correct answers on relevant MCQs…

What we need is the duration of time spent viewing each:

(a) image/case/webpage

(b) success on MCQ

Question:

Look at the images on the right. What injury(s) do you see? Select all that apply.

Multiple Choice Answer:

A	✗	☐	Soft tissue swelling
B	✗	☑	Medial malleolar fracture
C	✗	☐	Distal fibular fracture
D	✓	☑	Widened mortise joint
E	✗	☑	Posterior malleolar fracture
F	✓	☐	Talar fracture

Please note: ✓ ✗ show whether YOUR choice is correct or not, to toggle highlight what the expert selected, **please click here!**

AP, mortise view, lateral view

(Card 5, MSK Trauma)

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ADDITIONAL COVARIATES

Does a learner's…

(a) Demographic, School

(b) Total time on the module

(c) Total performance on multiple choice questions

(d) Completion rate
(aka. The number of cards completed)

…correlate with learning?

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PHASE 2

EXPLORING THE DATA

user_id	group_id	school	course_id	case_id	case_name	case_creation_date
150301	2280	iIntime Individual Subscribers	6220	226210	(CORE 16 V2) 16. MSK: Trauma	1/30/15 10:08
175964	2102	Duke	6220	226210	(CORE 16 V2) 16. MSK: Trauma	7/4/14 15:42
192763	2070	Harvard	6220	226210	(CORE 16 V2) 16. MSK: Trauma	11/19/14 20:11
203883	2135	Brown-Alpert	6220	226210	(CORE 16 V2) 16. MSK: Trauma	12/21/14 21:41
210022	2136	MU South Carolina	6220	226210	(CORE 16 V2) 16. MSK: Trauma	7/22/14 13:10
212749	2162	MC Wisconsin	6220	226210	(CORE 16 V2) 16. MSK: Trauma	3/29/15 23:59
213233	2162	MC Wisconsin	6220	226210	(CORE 16 V2) 16. MSK: Trauma	3/30/15 6:46
217048	2211	Virginia College of Osteopathic Medicine	6220	226210	(CORE 16 V2) 16. MSK: Trauma	1/23/15 13:53
220289	2136	MU South Carolina	6220	226210	(CORE 16 V2) 16. MSK: Trauma	11/26/14 5:20
222310	2025	Loma Linda	6220	226210	(CORE 16 V2) 16. MSK: Trauma	4/24/15 4:04
223938	2048	Emory	6220	226210	(CORE 16 V2) 16. MSK: Trauma	3/1/15 23:46
228706	2030	UC Davis	6220	226210	(CORE 16 V2) 16. MSK: Trauma	2/17/15 23:34
228814	2129	Pittsburgh	6220	226210	(CORE 16 V2) 16. MSK: Trauma	11/15/14 3:11
229777	2061	Kansas	6220	226210	(CORE 16 V2) 16. MSK: Trauma	8/28/14 3:29
230568	2059	Indiana	6220	226210	(CORE 16 V2) 16. MSK: Trauma	11/21/14 18:01
230667	2025	Loma Linda	6220	226210	(CORE 16 V2) 16. MSK: Trauma	11/14/14 6:22
230702	2061	Kansas	6220	226210	(CORE 16 V2) 16. MSK: Trauma	8/26/14 14:10
231429	2087	Dartmouth	6220	226210	(CORE 16 V2) 16. MSK: Trauma	7/2/14 12:32
231575	2059	Indiana	6220	226210	(CORE 16 V2) 16. MSK: Trauma	1/23/15 17:53
231726	2011	Temple	6220	226210	(CORE 16 V2) 16. MSK: Trauma	4/13/15 18:24

(Screenshot of Historical MedU Dataset)

DATABASE LIMITATIONS

Database items collect data on four of the five suggested CAMs. They are:

(a) Post-answer feedback

(b) Supplementary link click

(c) Zooming-in on images

(d) Time duration

Table 3. MedU Database Items Measuring the Five Chosen CAMs.

CAM	Database Item Collected (per user)
Thumbnail click	None
Post-answer feedback use	Number of clicks on "expert" links
Supplementary link click	Number of clicks on hyperlinks (excluding "expert" links)
Zooming-in on images	Number of clicks on magnify icons
Duration on cases/images	Number of seconds spent on a single card or module

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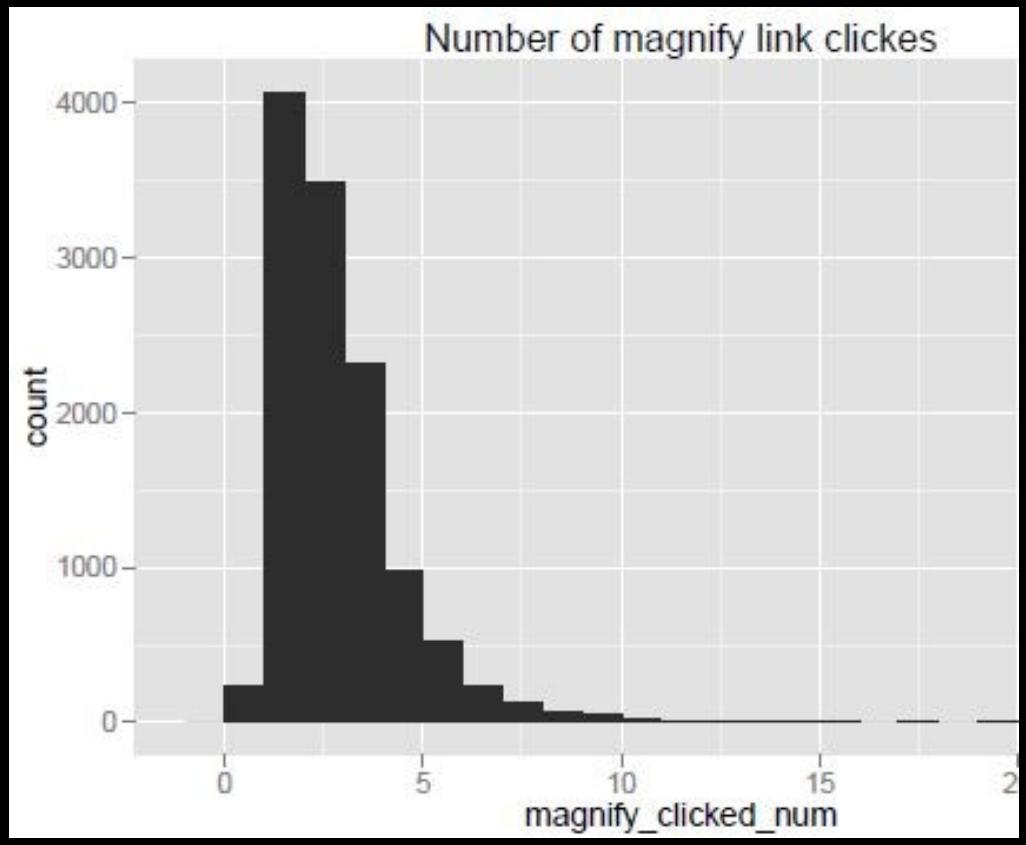
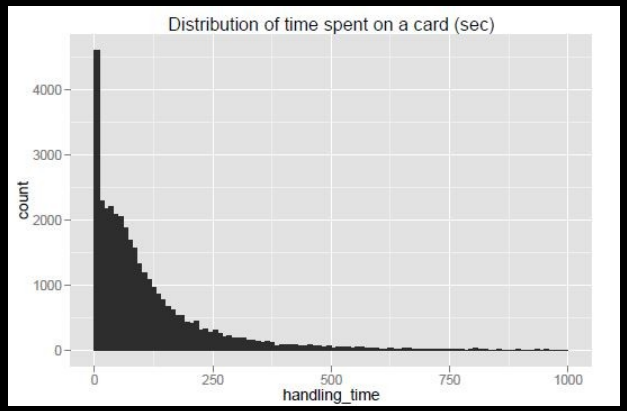
PHASE 3

INITIAL ANALYSIS

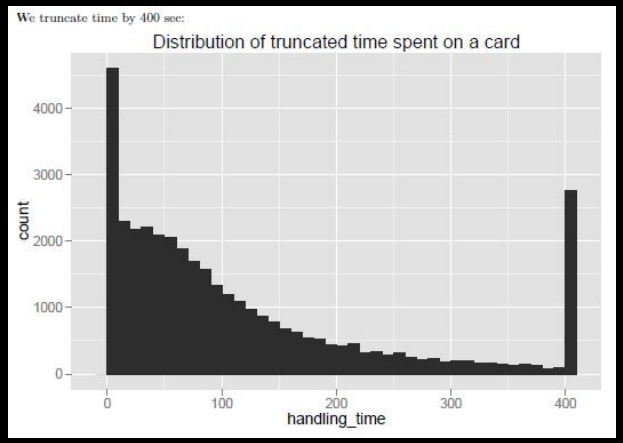
Bar charts were created to explore click counts and handling time durations per card…



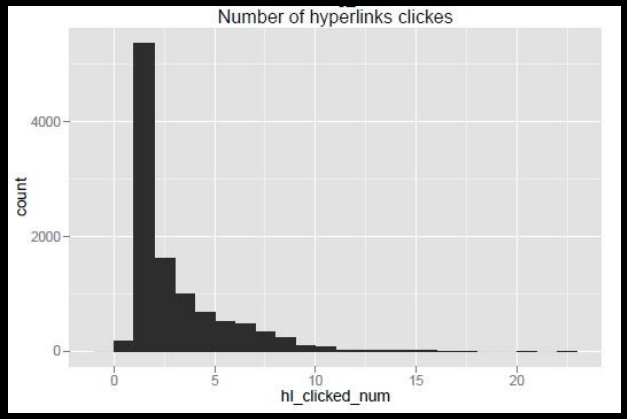
HANDLING TIME



HANDLING TIME (TRUNCATED)



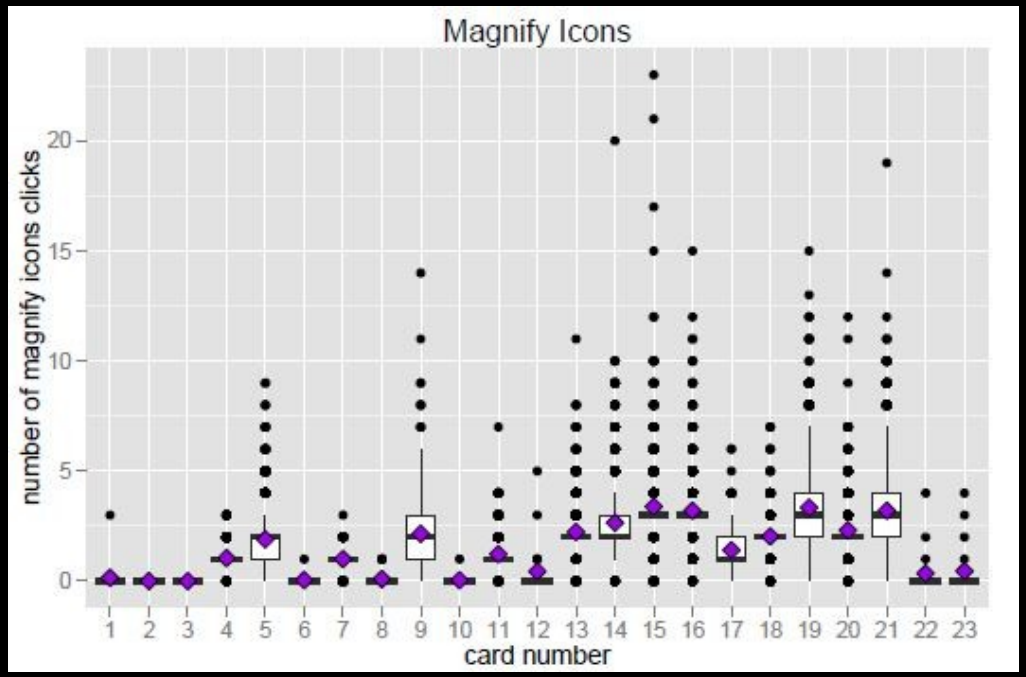
HYPERLINK CLICKS



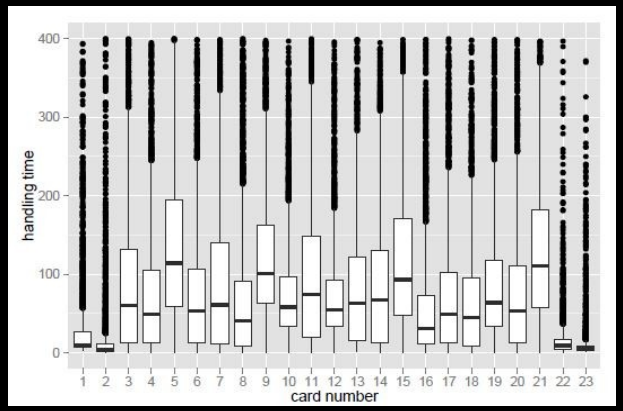
INITIAL ANALYSIS

…and box plots illustrated the number of clicks per card for each CAM measurement item.

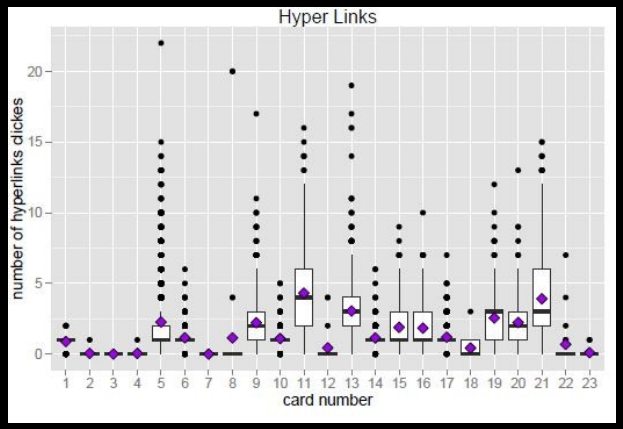
But, before we can agree with these figures, database collection mechanisms must be confirmed with the in-house MEDU team.



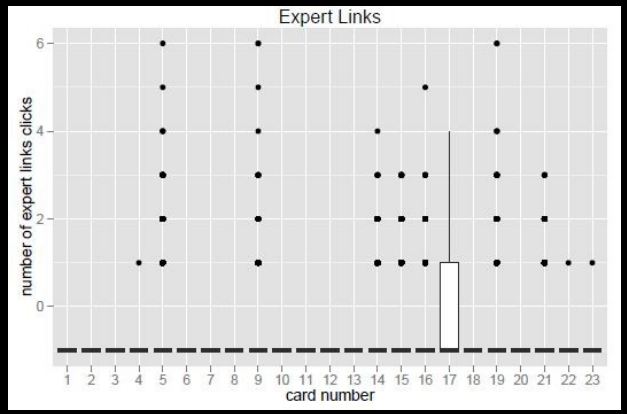
HANDLING TIME



HYPERLINK CLICKS



EXPERT LINK CLICKS



CONTINUING RESEARCH

In keeping with the initial goals (and following the confirmation of MEDU's click collection mechanisms), the final data analysis will include:

(a) Simple associations

(1) Success rate on MCQs ←→ Number of hyperlinks clicked
(2) Success rate on MCQs ←→ Time spent on cards
(3) Success rate on MCQs ←→ Number of clicks on image magnification
(4) Number of "expert" links clicked ←→ Number of hyperlinks clicked
(5) Number of "expert" links clicked ←→ Time spent on cards

(b) Regression analysis (i.e. 2-way ANOVAs)

(1) Success on MCQs
(2) Time on cards
(3) Interaction

(c) Conclude on whether these CAMs are useful predictive analytics

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THANK YOU FOR LISTENING

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