Exploratory Analysis: 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.

CONCEPTUAL MODEL FOR ENGAGEMENT

ADAPTIVE LEARNING SYSTEM: COMPONENTS AND DATA FLOW

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.)

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

Submit  Answers given so far: 2

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

Your next patient is Mr. O'Neill, 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.

**Question:**

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

**Multiple Choice Answer:**

A  [x] Posterior shoulder dislocation
B  [✓] Anterior shoulder dislocation
C  [x] Superior shoulder dislocation
D  [✓] Proximal humeral fracture
E  [✓] Acromio-clavicular joint dislocation

Please note:  ✓ x 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 subcoracoid 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.
FOCUS GROUP RESULTS

PHASE 1

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

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</table>
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…”
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...”
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...”
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...”
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.”
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
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.

EXAMPLES OF CAM-A

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

Weber ankle fracture classification

The Weber ankle fracture classification is a simple system for classification of lateral malleolar fractures, relating to the level of the tibiofibular syndesmosis. This classification system helps to guide treatment.

**Type A**
- On the lateral ankle, the fibular fracture is below level of tibiofibular syndesmosis
- On the medial malleolus, the deltoid ligament is intact
- As the syndesmotic ligaments (ligaments maintaining the tibiofibular articulation and stability) are intact, the ankle mortise is also stable
- These fractures are usually stable and treated with walking cast

**Type B**
- The distal fibular fracture is at the level of the syndesmosis, extending superiorly and laterally up the fibula
- The medial malleolus may be fractured or have widening of the medial joint space consistent with medial deltoid ligament injury
- These are of variable stability and frequently need fixation.

An additional helpful view for treatment planning is the “gravity stress view.” This view is obtained when a block is used to support the lower leg and the ankle/foot are allowed to fall under gravity. This positioning stresses the medial ankle ligaments and in cases of ruptured ligaments, the medial ankle mortise widening. The fracture with such ligamentous injury is unstable and in need of repair.

The patient underwent follow up imaging after ORIF with a lateral plate and a screw through the syndesmosis (green arrow).

**Type C fracture**
- The fibular fracture is above the level of the syndesmosis
- Tibiofibular syndesmosis disrupted with widening of the distal tibiofibular articulation
- Medial malleolus fracture or deltoid ligament injury present
- Unstable, requires surgery

At first, a high Weber C fractures occur in the fibular fracture being located in the proximal fibula resulting from propagation of the injury forces up through the interosseous membrane with a proximal exit point. These fractures are not visualized on ankle x-rays but can be evaluated with a lower leg tibia/fibula.

As is common in the fracture world, this Weber type C fracture pattern with proximal fibular fracture is named after a dead white guy...a French one in this case. Can you name the fracture?
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)
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)
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.

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
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
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.

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:**

- 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)
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
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?
### PHASE 2

**EXPLORING THE DATA**

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(Screenshot of Historical MedU Dataset)
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.

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<td>Supplementary link click</td>
<td>Number of clicks on hyperlinks (excluding “expert” links)</td>
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<td>Zooming-in on images</td>
<td>Number of clicks on magnify icons</td>
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<tr>
<td>Duration on cases/images</td>
<td>Number of seconds spent on a single card or module</td>
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</table>
Bar charts were created to explore click counts and handling time durations per card...
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.
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 $\leftrightarrow$ Number of hyperlinks clicked
2. Success rate on MCQs $\leftrightarrow$ Time spent on cards
3. Success rate on MCQs $\leftrightarrow$ Number of clicks on image magnification
4. Number of “expert” links clicked $\leftrightarrow$ Number of hyperlinks clicked
5. Number of “expert” links clicked $\leftrightarrow$ 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
THANK YOU FOR LISTENING

For further information, feel free to contact us at:

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