Implementation and Initial Experience Using a Web-Based, Rapid-Fire Teaching System with Game-Like Elements for Chest Radiography

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Background

Reinforcement learning theory posits that a learner's decision gains value proportional to the discrepancy between the predicted and the actual outcome in reward or punishment (1,2). Rapid-reinforcement feedback mechanisms also contribute to an experiential optimum known as “flow,” an “overwhelming proportion of [which occur] within sequences of activities that are goal-directed and bounded by rules” (3). These theories are an important part of software engineering, responsible for generating interest in otherwise mundane tasks such as stacking nondescript tile quartets in endless layers (also known as Tetris®), delivering lollipops to large-eyed green animals using Newtonian physics (Cut the Rope®), or in “first person shooter” video games (4,5).

Research suggests that two primary modes of knowledge acquisition comprise the learning process: explicit versus implicit learning (6). In explicit knowledge acquisition, a trainee consciously studies a textbook or attends didactic lectures. In implicit learning, a trainee acquires skill without trying to learn but instead by processes of stimulus-response binding (6).

Therefore, delivering rapid, immediate, unambiguous feedback may be an effective mechanism for learning radiology. Elements of technology-aided radiology education have been discussed previously (7). However, in diagnostic radiology, a paucity of opportunities exists outside of clinical service for active implicit reinforcement.

Previously, we created a rapid-fire digital teaching system to compress the core image interpretation experience as a proof of concept (8). In this experience report, we share the first findings of user experiences using this teaching system to practice chest radiography under time pressure.

Case Presentation

We created the “Centaur” application using PHP, HTML5, and JavaScript, powered by a MySQL database. An XML parser is implemented in PHP, and individual modules are defined using an XML language.

The overall system is designed to create a high-tension scenario in which a full day's volume of chest radiographs is compressed into a 20-minute experience. In this approach, users may be more likely to rely more on experiential learning rather than on conscious cognitive analysis.

The chest radiography module is assembled using 74 cases. Each case may be a normal chest radiograph (32 cases) or may contain one of the following findings: a focal opacity (17 cases), a pneumothorax (9 cases), or a solitary pulmonary nodule (16 cases). Cases were reviewed and chosen by two board-certified radiologists with 5 and 7 years of experience, respectively. For each case, the participant is tasked with identifying the
category and laterality (left or right) of the abnormality on the radiograph, or indicating that the image is normal.

Clicking on any one of the seven responses elicits the immediate feedback mechanism, consisting of three elements: (A) color-coded feedback for correct and incorrect responses, (B) an animation displaying the point earned, and (C) an annotated explanation. For the chest module, users earn 1 point for correct answers but are not penalized for incorrect or unanswered cases. An example case using chest radiograph is shown in Figure 1a, and the result of an incorrect answer choice is shown in Figure 1b.

**Figure 1**

![Figure 1a and Figure 1b]

For each case, the user is shown a 15-second countdown timer. The system scores the case as incorrect at the depletion of the time limit. Extra time is not rolled over to the next case; each case is presented for no more than 15 seconds.

Prior to the start of the module, participants are shown a brief survey requesting simple demographic information. At the end of the module, the system shows a survey presenting questions in a Likert-like scale to collect user impressions. Table 1 shows a detailed accounting of the questions asked.

**Table 1**

<table>
<thead>
<tr>
<th>At the Start of Module</th>
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<tbody>
<tr>
<td>Please indicate your level of medical training.</td>
<td></td>
</tr>
<tr>
<td>Approximately how many months of training/practice do you have in the interpretation of chest radiographs?</td>
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<table>
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<tr>
<th>At the End of Module</th>
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<tbody>
<tr>
<td>Please rate your agreement with the following statement:</td>
<td></td>
</tr>
<tr>
<td>Traditional methods of learning to differentiate normal from abnormal chest radiographs (i.e.- textbooks, workstation readouts, conferences, etc) are an efficient means of learning.</td>
<td></td>
</tr>
<tr>
<td>Traditional methods of learning to differentiate normal from abnormal chest radiographs (i.e.- textbooks, workstation readouts, conferences, etc) can be improved upon.</td>
<td></td>
</tr>
<tr>
<td>The following questions pertain to modules such as the one you just completed, including normal and abnormal radiographs with rapid feedback.</td>
<td></td>
</tr>
<tr>
<td>These modules are an efficient means of learning.</td>
<td></td>
</tr>
<tr>
<td>These modules are helpful for training medical students learning to differentiate normal from abnormal chest radiographs.</td>
<td></td>
</tr>
<tr>
<td>This style could be used, and would be helpful, for learning normal versus abnormal findings in other radiology modalities (for example VQ scans and different forms of intracranial hemorrhage).</td>
<td></td>
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</table>
At the end of the module, participants receive their tabulated score showing both the total points and performance subdivided by each finding. Between July 2014, and December 2015, we asked radiologists with various experience levels to complete this module.

Outcome

The chest radiography module takes approximately 20 minutes to complete all 74 cases. 33 radiology residents, 5 radiology fellows, 1 radiology attending, and 1 medical student completed the module. Most users were trainees with no prior experience (60%). Figure 2 shows participants' reported experience in chest radiology in months of experience.

Most respondents (73%) are either neutral or somewhat agree that traditional methods to learning chest radiography, defined as textbooks, workstation readouts, and conferences, are an efficient way of learning. 85% somewhat agree or strongly agree that traditional methods have room for improvement. A majority of respondents (88%) either strongly agree or somewhat agree that the Centaur rapid-fire teaching system is an efficient means of learning. 45% of the respondents strongly agree that the software would be helpful for training medical students. 58% strongly agree that it can be applied to modalities other than chest radiography. The full range of survey responses is shown in Figures 3 through 6.
Figure 4

These modules are an efficient means of learning

Figure 5

These modules are helpful for medical students
Discussion

Our survey results show that most users are junior residents for whom acquiring a “gestalt” for chest radiography is one of the earliest challenges in learning the radiology craft. Among the user population, the learning platform is well received and is felt to be translatable to medical students and to other modalities.

In early testing prior to implementation, we found that some participants preferred to hide the timer while others prefer to increase its visibility to keep abreast of the time constraint. In actual implementation, we elected to create a movable timer which a user may place anywhere, including moving it off screen.

Future directions for this project include additional data analysis as well as comparing junior residents, senior residents, and attending level radiologists. The web-based platform enables comparison between trainees from different residency programs across the country or even world. Based on the findings of this study, we wish to create modules for other modalities, such as nuclear scintigraphy or bone radiography. Furthermore, the module may be used as a standardized methodology of longitudinally measuring residents’ progress through their training to study the evolution of their practice patterns. The module can potentially serve as a methodology for an additional visual pattern recognition training system incorporated into the traditional metrics of residency training.

Several factors contribute to variations in our findings. Because the module is web-enabled and works on several different configurations, the user experience is not fully standardized. For instance, whether all participants used comparable hardware setup is unclear; the diagnostic quality on a mobile phone may differ from that on a large monitor. While the module recommends at least a 10” screen with mouse access, for compatibility and educational convenience, the software allows users to complete the modules using a mobile phone if he/she chooses.
Conclusion

Our initial experience showed positive opinions from module participants suggesting that a web-based rapid-fire teaching case module may be an effective means to teach core elements in chest radiography in a game-like experience. Similar mechanics may be translated to other modalities such as nuclear medicine or bone radiography.

References


Keywords

Teaching Files, Education, Gamification, Web-Based, Chest Radiology