CBL on FHIR: A FHIR-Based Platform for Health Professional Education

Mark Braunstein, [a,1] Ben Barry, [b] Jim Steel, [a] Deanne Ukovich, [a] John Grimes, [a] David Conlan, [a] Sophie Jones, [c] Chelsea Dobbins, [b] David Hansen [a]

[a] *CSIRO Australian e-Health Research Centre*
[b] *The University of Queensland*
[c] *The University of Melbourne*

ORCiD ID: Mark Braunstein https://orcid.org/0000-0002-1157-9623, Ben Barry https://orcid.org/0000-0002-5853-940X, Jim Steel https://orcid.org/0000-0002-5694-1147, Deanne Ukovich https://orcid.org/0000-0003-2007-240X, John Grimes https://orcid.org/0000-0002-9575-7641, Chelsea Dobbins https://orcid.org/0000-0001-9420-2452, David Hansen https://orcid.org/0000-0002-2998-4563

Abstract. A FHIR based platform for case-based instruction of health professions students has been developed and field tested. The system provides a non-technical case authoring tool; supports individual and team learning using digital virtual patients; and allows integration of SMART Apps into cases via its simulated EMR. Successful trials at the University of Queensland have led to adoption at the University of Melbourne.

Keywords. Case-based learning, problem-based learning, FHIR, SMART, SMART apps, virtual patients, team learning, group learning

1. Introduction

We previously reported a prototype of CBL on FHIR, an innovative, digital approach to Case Based Learning for health professional students. We argued that it might overcome some of the known shortcomings of traditional paper or PDF based cases by simulating care through interaction with virtual patients while exposing them to modern digital clinical tools. [1] Here we report on a fully functional, field-tested version.

2. Methods

CBL on FHIR is a digital case-based learning tool developed using HL7's Fast Interoperability Resources (FHIR) standard [2] and SMART, an app platform built on FHIR [3]. These modern technologies provide several potential benefits:

- Leveraging FHIR and SMART positively impacts the speed and cost of development and ongoing maintenance of EHR connected tools.
- Cases and apps can potentially operate in conjunction with most major EHR systems if they support FHIR and SMART.

---

[1] Corresponding Author: Mark Braunstein, mark.braunstein@csiro.au

- Existing SMART apps and new SMART apps for education can expose students to digital tools they will increasingly use in their future practices.

2.1 Modules

CBL on FHIR consists of five modules:

Case Authoring: An interactive tool for non-technical clinician authors to create, edit, revise, and share cases with automated coding into appropriate data standards.

Student Landing Page, Case Player and Simulated EHR: Individual students or student teams/groups access their individual unique copy of current and past cases.

Manager Console: To assign cases to courses along with their start and stop dates.

Tutor Dashboard: To review student progression and review any feedback or questions.

Reports: The Australian e-Health Research Centre's (AEHRC) Pathling FHIR tool, a "FHIR Analytics API", [4] provides a simple to use reporting capability.

2.2 Case Authoring
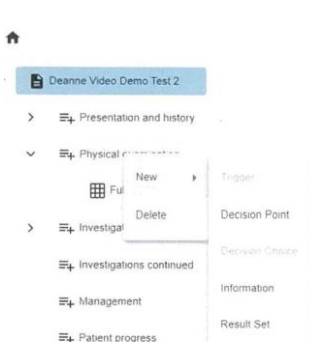
To construct a case and its virtual patient, authors add elements to a hierarchy (Figure 1). **Triggers** (sections) that can include **Discussion questions** and associated answers; **Decision Points** to challenge students to choose from a list of clinical actions (and, optionally, receive feedback); **Information** to provide case details; and **Result Sets** that are predefined or customizable templates for vital signs, physical examination results, laboratory tests, imaging studies, or any other predefined data set such as questionnaires.

Figure 1: Cases are a hierarchy of Trigger, Decision Point, Information and Result Set elements.

Authors can create new cases and preview, publish, duplicate, edit, delete, or share existing cases. Descriptive case metadata assists identification by other instructors.

Templates (Figure 2) can include normal ranges and units of measure, so case authors need only provide the appropriate value for a specific point in the case. Fields are pre-coded into SNOMED CT or LOINC. Encounters, social determinants, procedures and condition lists, medications and adverse reactions can also be coded.

Figure 2: A Result Set is a predefined template used for vital signs (shown here), physical examination results, laboratory tests, imaging studies, questionnaires or other author defined forms. Normal ranges and units of measure can be pre-defined to save case authors' time.

2.3 Simulated EHR

Case definitions includes the text the student will see as the case is played; optional text that only the mentor/tutor will see; the elapsed time since the last trigger to provide an appropriate age for the patient and appropriate relative times and dates for information stored in the EHR; and patient details specific to this trigger (e.g., location, weight for dose calculation, resuscitation status).

The case author specifies the information to display in the simulated EHR when the student reviews this part of the case (also, students can directly record into the EHR). EHR information is coded in widely used global health data terminologies (such as SNOMED CT [5] and LOINC [6]), in the background using dynamic drop-down lists provided by the Australian eHealth Research Centre's Ontoserver, a terminology server [7]. Case authors and students need no knowledge of the terminologies. Once coded, the information is available to any SMART apps linked by the case author to the case. We contend that scaffolded use of terminology tools provides an excellent learning experience for students. We also contend that this experience with clinical terminology is best gained prior to work placements in hospitals and other clinical settings.

2.4 Case Player

The students view cases (Figure 3) via a simulated EHR with a left function menu and key patient information at the top. The simulated EHR is a SMART app with the "Case" below any SMART Apps linked by the author to this case. As with commercial EHRs, the Case and any other SMART apps operate within the area of the simulated EHR screen also used for charting and information retrieval. Case presentation can consist of text, images and, as illustrated here, videos (a history taking session from which students are challenged to extract and chart relevant information). Each student has their own case instance with a unique identifier. As shown, they can highlight information and add notes. If the student revisits the case, all stored data, including their annotations, are displayed up to the point in the case the student last reached.
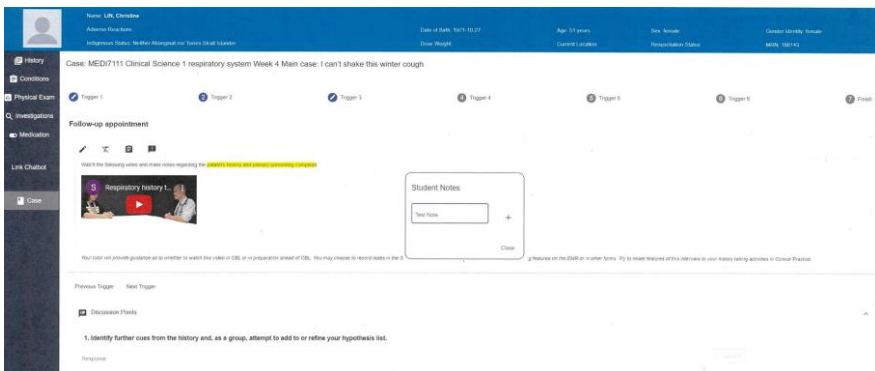

Figure 3: The Case Player SMART app simulates an EHR with functions along the left and key patient information at the top. It operates in the central area used for EHR charting and review. Students have a unique copy of the case and, as shown, can highlight information or add notes that are stored for later review.

The case in Figure 4 presents a 68-year-old woman with hypertension and symptoms of congestive heart failure. The calculation of atherosclerotic cardiovascular (ASCVD)

risk is appropriate, so the case author has linked it to Cerner's free, open-source ASCVD Risk Calculator app [8]. Using SMART launch, the app has accessed the patient's age, gender, and SNOMED CT or LOINC coded serum lipids.
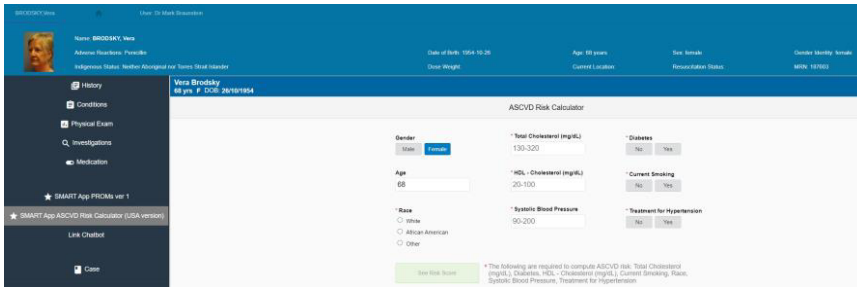

Figure 4: Cerner's ASCVD Risk Calculator SMART app, with permission granted by SMART scopes, has accessed the patient's age, gender, and serum lipids at its launch.

3. Results

Over the past 4 years, 12 instructors at The University of Queensland, created 74 cases taken over 3500 times by over 1000 medicine, nursing, and pharmacy students in 8 courses. The University of Melbourne School of Health Sciences faculty has developed 26 cases used by 520 nursing and physiotherapy students. Data is stored in FHIR format, so AEHRC's Pathling can provide analytics. Figure 5 is a request for the number of students and their status for each case (represented using FHIR's Questionnaire resource).
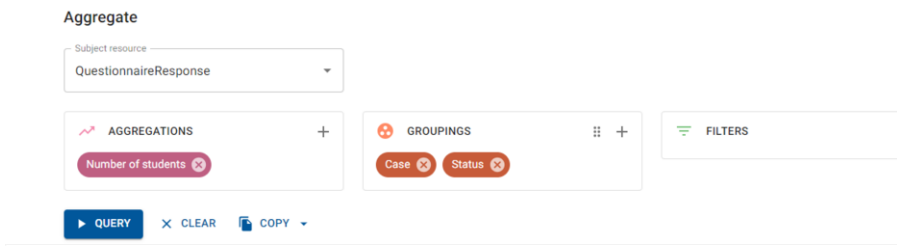

Figure 5: A Pathling report request for the number of students and their status for each case.

4. Discussion

Two universities have developed 100 cases used by students in four health professions. CBL on FHIR now also supports student groups – where notes are shared between all group members; and teams – where team member roles are assigned or

negotiated and decisions and EHR notes are circumscribed for these users. This collaborative case engagement simulates clinical team practice. The platform can be used synchronously online or in the classroom, or asynchronously by students working remotely. The FHIR CareTeam resource [9] represents the student team members, and all roles are SNOMED CT coded. A specific SMART app supports the formation of teams and allocation of roles. At case launch in Team mode, trigger progression is locked depending on the role of a care team member. These team features are yet to be field tested. Student teams in the University of Queensland's COMP3820 FHIR based Digital Software Project course can elect to develop SMART FHIR apps for use on the platform. This is likely to grow with the increasing popularity of the course that most recently enrolled 73 students. [10]

5. Conclusions

Based on its acceptance and repeated use by faculty and students from four health disciplines at two Australian universities, CBL on FHIR has proven to be a workable approach to case-based learning. It has also proven to be a platform for collaboration between health professional and COMP3820 IT students. The resulting apps, when linked to the platform, may provide a response to the call by a recent NEJM article *Preparing Physicians for the Clinical Algorithm Era* that as "CDS algorithms play a growing role in clinical care" medical students "Practice interpreting CDS output in applied learning" by "Applying CDS algorithms to individual patients." [11]

Based on results to date, efforts are underway to further extend and broaden CBL on FHIR's use in Australia and beyond.

References

[1] Braunstein, ML, Oancea, J, Barry, B et al. The development and electronic delivery of case-based learning using a fast healthcare interoperability resource system, *JAMIA Open*, Volume 2, Issue 4, December 2019, Pages 440–446
[2] HL7 Fast Healthcare Interoperability Resources (FHIR), http://hl7.org/fhir/
[3] SMART Health IT, https://smarthealthit.org/
[4] Grimes, J., Szul, P., Metke-Jimenez, A. et al. Pathling: analytics on FHIR. *J Biomed Semant* 13, 23 (2022).
[5] SNOMED CT, https://www.snomed.org/
[6] LOINC, https://loinc.org/
[7] Metke-Jimenez A, Steel J, Hansen D, Lawley M. Ontoserver: a syndicated terminology server. *J Biomed Semantics*. 2018 Sep 17;9(1):24.
[8] ASCVD Risk Calculator, Cerner Corporation, https://apps.smarthealthit.org/app/ascvd-risk-calculator
[9] FHIR CareTeam Resource, https://www.hl7.org/fhir/careteam.html
[10] COMP3820 Digital Software Project Course, https://my.uq.edu.au/programs-courses/course.html?course_code=COMP3820
[11] Goodman, KE, Rodman, AM, Morgan, DJ. Preparing Physicians for the Clinical Algorithm Era. *New England Journal of Medicine*, August 10, 2023, 389;6.