Design of an eOSCE for the Chilean Healthcare Context

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Abstract—Objective Structured Clinical Examination (OSCE) is the standard to assess and train clinical skills in healthcare students. However, conducting an OSCE demands expensive resources such as time, qualified personnel, and adequate facilities. The aim to provide more cost-effective examinations has promoted the emergence of electronic versions of OSCEs (eOSCEs). However, existing eOSCEs available in the market do not adequately adapt to diverse local contexts. For a Spanish-speaking country such as Chile, implementing foreign eOSCEs requires to adjust the examination to unfamiliar terminology, archetypes, and procedures, thus hindering the quality of the assessment. This article reports on the design of Ch-eOSCE, an eOSCE tailored for the Chilean local context and culture. Ch-eOSCE is comprised of a mobile application and a back-end system. A prototype of the application was developed and tested with three healthcare experts to gather their perception of usability and coherence, yielding an overall evaluation of 4.5 in a scale range of 5. The preliminary results reveal that Ch-eOSCE has the potential to become a viable solution for a context-specific eOSCE for the Chilean healthcare context.

Keywords—objective structured clinical examination, OSCE, assessment, Chile, healthcare training, local culture

1 Introduction

Objective Structured Clinical Examination (OSCE) is the standard method to assess and train clinical skills in healthcare students. Since its development in the mid-'70s by R.M. Harden [1] it has been widely used in clinical education [2]–[4]. The OSCE usually consists of a series of stations, where trained actors play the role of patients seeking clinical attention. Students go through each station in a limited time, examining or interviewing the patient to elaborate on a diagnosis. Medical professionals evaluate the students' clinical reasoning skills using a paper-based checklist to score their performance [5].

The OSCE offers students the benefit to rehearse and enhance their skills through a simulation conducted by health professionals with vast clinical experience [6]. However, conducting an OSCE in an academic environment with a large number of students requires several hours from qualified personnel, economic resources to compensate actors and health professionals, and considerable physical space [1], [7]. Consequently, for many educational institutions, implementing OSCEs on a regular basis is a taxing task [8]. In addition, the use of analog systems during the examination usually delays immediate feedback and is prone to errors when transcribing scores to digital mediums [6], [9]–[11]. The increasing use of interactive software systems for the medical education process [12], along with the need for a more efficient and economical assessment has paved the way for the emergence of digital versions of the OSCE [11], [13]–[15]. Electronic OSCEs (eOSCEs) can emulate the traditional exam through digital mediums that are particularly attractive for young students, such as mobile applications [16]. The use of eOSCEs lowers implementation costs, accelerates feedback delivery [17], and enables students to train with more frequency and ease [18].

But responding to the diversity of linguistic, cultural, and socioeconomic differences between countries is a challenge for eOSCE implementations. Most eOSCEs available in the market use English as their primary language, and even though some offer language selection options, a direct translation does not necessarily respond to the linguistic nuances between countries. In an OSCE context, the nuances in conversational language are critical to realistically simulate a local patient seeking medical attention. For instance, the words used to say “abdominal pain” are quite different in Chile and Colombia, despite the fact that Spanish is the official language in both countries. On the other hand, each country has its own standard procedures, and its own set of approved and available drugs. Not considering these distinctions in an eOSCE implementation might render it unsuitable for educational purposes. Hence, the implementation of eOSCEs remains limited for Spanish-speaking countries such as Chile. The need for an eOSCE that can genuinely represent the Chilean context inspired the work presented in this article. This article reports on the design process and initial evaluation of a Chilean electronic OSCE (Ch-eOSCE) prototype, specifically tailored to the Chilean healthcare context and culture. The project is the beginning of the development of an easily available digital tool for healthcare students in Chile, intending to foster frequent practice, a critical aspect for the development of clinical skills [2].

2 Methods

2.1 Design

The Ch-eOSCE project detailed in this article was a collaboration between the School of Design and the School of Medicine at Universidad del Desarrollo in Chile. It originates from a call from the School of Medicine to develop a digital solution to conduct a virtual dialogue between a patient and a student in an OSCE context.

The long-term development strategy was defined at the beginning of the project. The design process was divided into several phases. As seen in Figure 1, the strategy is based on the development of a series of prototypes with distinct roles, ranging from initial exploratory prototypes [19] to a complete prototype to validate the whole proposed system. Upon the stage reported on this article, a mobile application prototype was developed and preliminarily tested with experts.

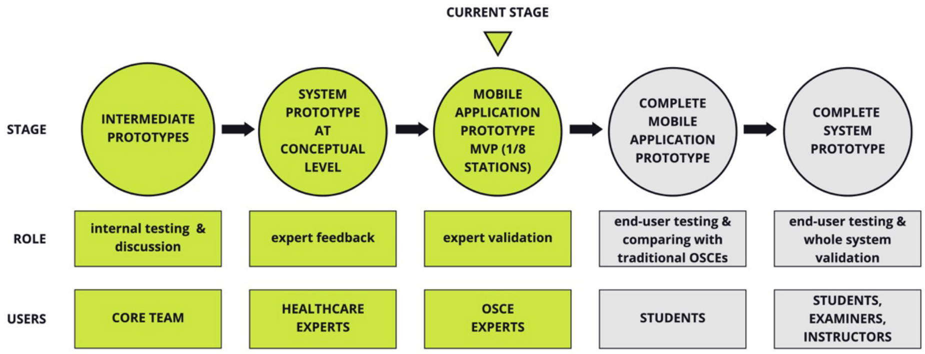

Fig. 1. Design strategy phases

In the first stage of the project, a series of intermediate prototypes were produced to define design attributes such as the role, look and feel, and implementation [20] of the system. The intermediate prototypes were used as a medium for decision-making within the core team, and a way to iteratively evolve the design towards the proposed Ch-eOSCE system.

The second stage included the development of a low-fidelity concept prototype, aimed to define aspects of user experience (UX), user interface (UI), and content narrative. It focused particularly on the interview system of the eOSCE and on the content. It was evaluated by experts from the School of Medicine at Universidad del Desarrollo, and their feedback informed the design adjustments for the following version.

In the third stage, a minimum viable product (MVP) was developed using an experimental prototyping approach, where a section of a system was developed to assess whether the solution satisfied the system requirements [19]. For the MVP, a mobile application with one of eight virtual OSCE stations was developed. The functional station was meant to act as a "research archetype" [21] with an adequate level of fidelity for initial user testing. The seven remaining stations were left as non-functional mockups. Since all the stations are similar in structure, the aim was to use this station as a model for the future development of the remaining stations.

2.2 Testing

A user test was performed to determine if the proposed MVP was adequate to assess clinical reasoning and to confirm that the design was evolving in the right direction. To obtain an early confirmation from experts, three healthcare professionals (two nurses and one doctor) with previous experience in the design and application of OSCEs were invited to blindly user-test the mobile application.

The test consisted in performing the developed station of the MVP. A room was prepared to give participants privacy while performing the test. A brief tutorial card was given at the beginning to instruct participants on its general operation. An Android mobile phone with the Ch-eOSCE application loaded was provided to perform the test.

After the test, the experts completed a short survey in *Google Forms* to evaluate the perception and usability of the application. The questionnaire consisted of four sections: introduction, background and expertise, evaluation, and opinions. The first section included a welcome message and an agreement to participate on the study. On the second section, participants provided basic background information, such as occupation and position. Participants were also asked to self-report their level of expertise applying traditional OSCEs using a seven point Likert scale (ranging from 1="novice" to 7="expert"). On the third section, participants were asked to rate their agreement with five statements on usability and ease of use using a five point Likert scale (1="strongly disagree" to 5="strongly agree"). Following each statement, respondents were asked to explain their choices using a space provided for short comments. Finally, the fourth section included four open-ended questions focused on their overall opinion and suggestions to improve the application.

After the questionnaire, a non-structured interview was conducted. The interviews were video-recorded. Participation in the user test was voluntary and the individual results were kept anonymous.

2.3 Data analysis

The scores obtained from the evaluation section were processed using descriptive statistics, yielding both results per question and overall performance. The comments from the open-ended comments following each statement were analyzed and organized into themes: ease of use, visual design, time assigned for questions, representation of clinical reasoning, depiction of local context, feedback, confusing aspects, and tutorial's usefulness. The comments were qualified as positive or negative. The open-ended suggestions gathered from both the fourth section of the questionnaire and the interviews were analyzed and organized into themes: visual and interface design, clinical reasoning, depiction of local reality, feedback given by the application, user instructions, and "other".

3 Design process

3.1 Patient case model

The first step towards the design of the Ch-eOSCE system was to model one patient case sample for one station of the mobile application. Two goals were established for the case design: represent an archetypical case of a Chilean patient attending a public care center in Chile, and lead to a unique and unmistakable diagnosis of a cardiovascular condition.

The model considered a profile design with basic information such as age, sex, weight, and contextual information. It also included vital signs readings such as blood pressure level, body temperature, oxygen saturation level, among others. Similarly, attributes such as ethnicity, socio-economic background, and lifestyle were defined to establish a credible archetype of a Chilean patient (Figure 2).

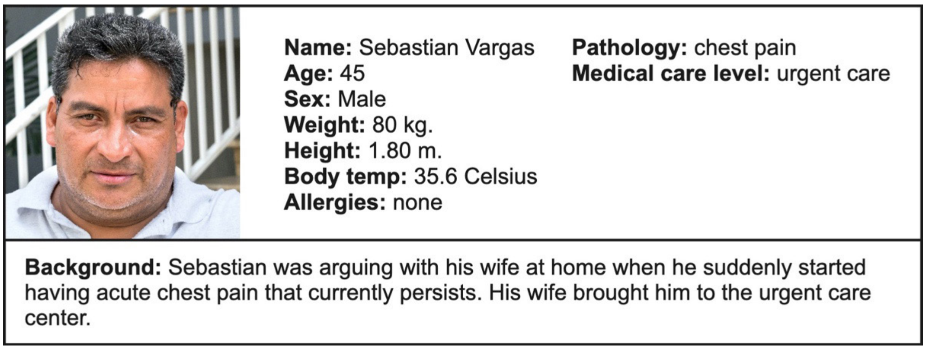

Fig. 2. The virtual patient's basic profile

3.2 Software development

The mobile application was developed in Unity 3D, a cross-platform game engine used to develop mobile, desktop, console, and virtual reality applications. Over the last few years, unity 3D has become increasingly popular for the development of interactive applications [22], [23], in part due to its multi-platform capabilities. Unity 3D features add-ons (called "assets" in Unity) such as GameCreator [24] and Dialogue [25] that can facilitate the development through visual scripting [23], which follows a similar logic to pseudo-code and Nassi–Schneiderman's diagrams [26]. This technique was coherent with the user experience requirements, where the conversation between the student and the virtual patient can take different paths depending on the sequence of questions chosen by the student. The benefit of this visual approach to programming was that the medical team could grasp the software's inner workings, thus facilitating the interdisciplinary collaborative work sessions. For this phase of the project, the Android platform was chosen for deployment because it holds 83.73% of the mobile market in Chile [27], thus presenting better chances of user-testing.

3.3 User experience and user interface

One of the goals of the system was to enable a simulation that resembled the setup of a traditional OSCE but without the associated implementation disadvantages. Accordingly, the application features a set virtual stations that the user visits to interact with patients. One of the biggest challenges was to achieve a natural patient-doctor dialogue when adapted to the form factors of mobile applications. After several design iterations, the choice was to use a chatbox configuration, a familiar format for young students (Figure 3).

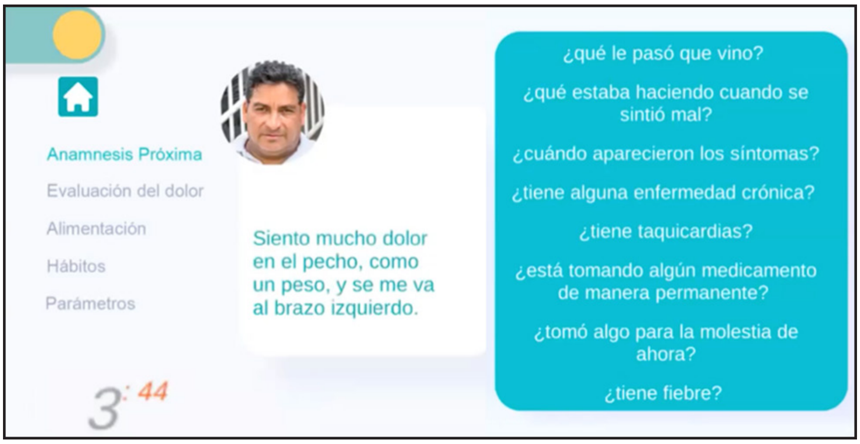

Fig. 3. The interview section of the application. The categories (left) define the pool of possible questions (right). The virtual patient responds in the white box (center)

The UX and UI design extensively embrace Grant's principles from "101 UX Principles" [28], that defines a set of considerations for user-facing digital applications. Some of the most essential considerations applied to the design of the MVP are explained below.

The graphical user interface (GUI) elements were designed to respect the principle of consistency. Throughout the whole application, icons, buttons, and navigation arrows have a coherent common style. The elements were designed using vector-based tools such as Adobe Illustrator, which supported a seamless integration with Unity's environment. The selection of typefaces was limited to a few, and Arial was used as the main typeface for the text fields for its ubiquity, readability, and good integration with the Android platform.

All back-end processes were left invisible to the front-end user, so they could focus on the interaction without being distracted by the software's technical operations. In cases where subprocesses take place (e.g. confirmation of a decision before continuing), visual cues were provided to indicate that further action would be required. Additionally, throughout the whole application, the user could always kill a subprocess and go back to the previous state (e.g. providing a "are you sure you want to …", "ok", and "cancel" buttons), thus embracing Grant's principle of allowing users to undo destructive actions (Figure 4).

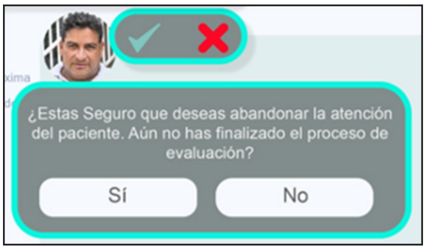

Fig. 4. A detail of a subprocess with a confirmation window. A pop-up window asks for confirmation before exiting the session when a diagnosis has not yet been determined

Some sections of the application required more complex interactions. For instance, on the "prescription" section the user had to select one or more drugs from a long list. Each selection required to specify the dose, units of measure, and frequency of administration. A combination of input text and drop-down menus was used for this task (Figure 5). Similarly, to determine a diagnosis, an input text field was provided. The diagnosis text, although free-form, had a limited character count to avoid obscuring relevant GUI elements, responding to the principles of size and sensibility. Additionally, in all cases where text input was required, the application made use of Android's default keyboard set to respect Grant's principle of privileging the use of the platform's native controls.

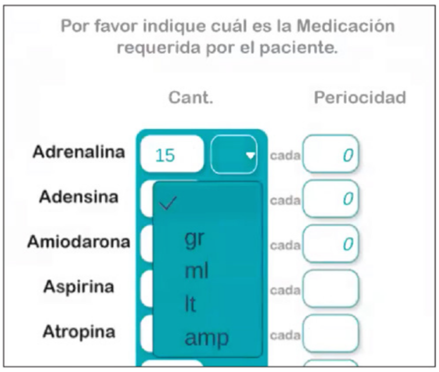

Fig. 5. A detail of the prescription interface. User can select from a list of drugs and determine dose, unit of measure, and frequency using the text input boxes and drop-down menus

4 Results

4.1 The Ch-eOSCE system

The Ch-eOSCE system addresses the diverse processes and components involved in the implementation of a traditional OSCE: design, application, evaluation, and feedback. Figure 6 shows the conceptual model of the system comprised of three interrelated interfaces, each one tailored towards different functions, roles, and users.

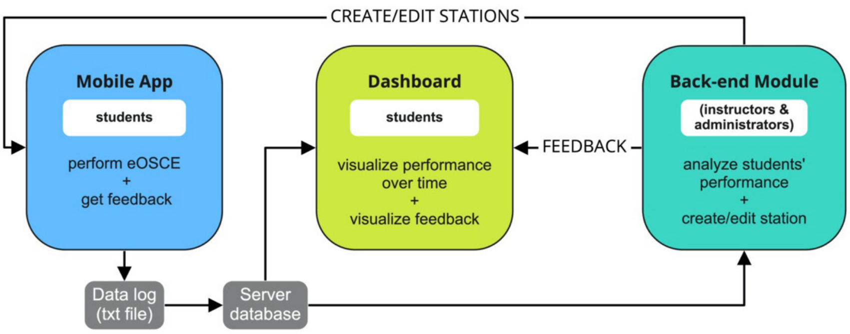

Fig. 6. Conceptual model of the Ch-eOSCE system

The first interface is an Android-based mobile application. With the application, students perform an eOSCE by going through a set of virtual stations in a limited time. The application computes and displays a performance score every time a station is completed, providing initial feedback to the student while more comprehensive feedback from the examiner is pending. The performance data is registered within the application and shared with the second and third interfaces, described below. For this stage of the project, the application was developed as a functional prototype.

The second interface is a web-based dashboard where students can visualize the result of the examination. Individual and collective (e.g. the whole class) performance results can be visualized and compared, providing the student a better understanding of their standing in relation to their peers, and to themselves along a period of time. For this stage of the project, the dashboard interface was developed as a low-fidelity prototype. The aim is to further develop this interface in the future.

The third interface is a web-based back-end module for examiners and instructors, where students' performance can be visualized over time, offering several comparison tools. This enables the mentors to establish academic strategies to enhance the students' clinical reasoning skills on an individual and collective basis. For this stage of the project, the back-end module was developed as a low-fidelity prototype. The aim is to further develop this interface to include editing capabilities in the future, where instructors can create and edit their own stations and assessment schemes.

4.2 Mobile application

The mobile application is the main interface where the OSCE examination takes place. As seen in Figure 7, the application has four main stages: login, home, station, and feedback. In the login stage the student registers and starts the session. In the home stage, the user selects stations to begin the simulation. In the station stage the student interacts with a virtual patient, performing three actions: interview, diagnose, and indicate treatment. The feedback stage visualizes the performance score and gives feedback to the student. The student can go back to the home screen and repeat the process by selecting another station.

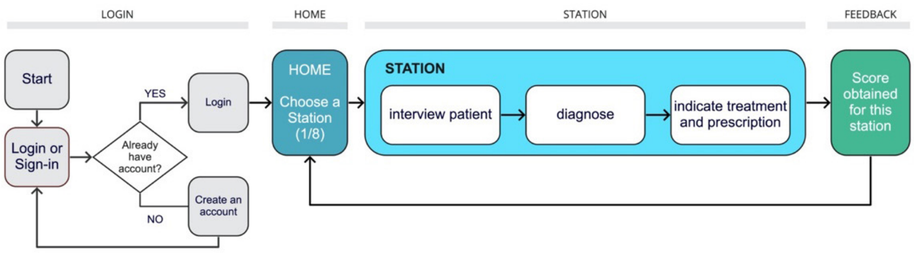

Fig. 7. Interaction flow of the application

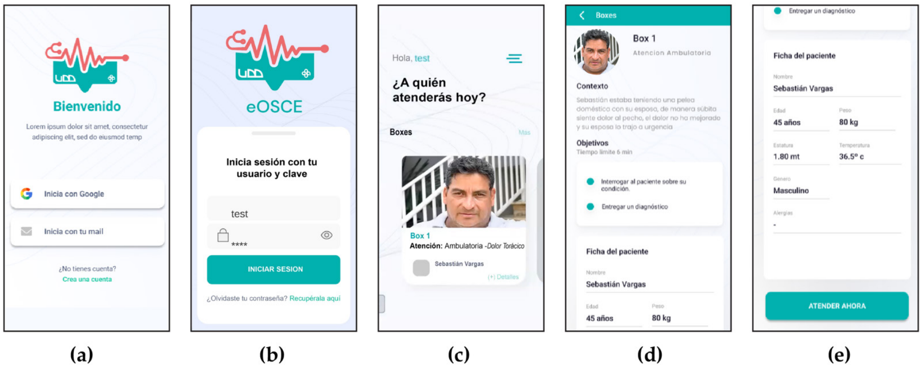

Fig. 8. (a) Start screen; (b) Login screen; (c) Home screen; (d) Background information screen; (e) Begin session screen

In the home screen (Figure 8(c)) the student can browse within eight stations (by swiping horizontally) to select one. Each station is represented by a thumbnail that displays the profile photo of the patient, name, and the type of attention needed (ambulatory, urgent, emergency). Once a station is selected, the station screen is shown (Figure 8(d)). Here, a short paragraph introduces background information about the patient. For example, the chest pain station reads: "*Sebastian was arguing with his wife at home when he suddenly started having acute chest pain that still persists. His wife brought him to the urgent care center*". Below, the goals of the activity are displayed in a short text: Interview the patient about his condition; Elaborate a diagnosis; Indicate a treatment. Next, the user can find the file of the patient with biometric data such as heart rate, blood pressure, oxygen saturation levels, among others. To begin the interview, a "begin session" button is provided at the bottom of the screen (Figure 8(e)).

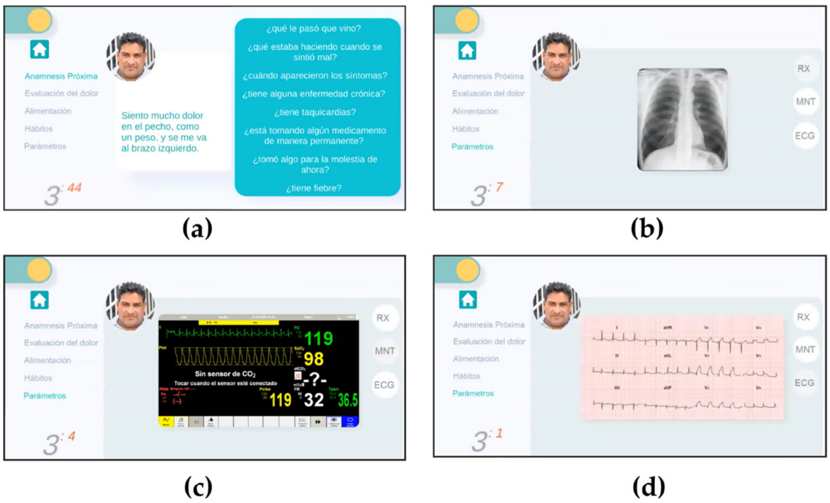

Fig. 9. (a) The interview screen; (b) (c) (d) Physical test results shown by pressing the buttons on the right side

The interview section features a category list, a list of questions, and a space for the patient's responses. On the left side of the screen, five categories are displayed: anamnesis, pain evaluation, patient's diet, and patient's habits. An additional category of "parameters" offers results from physical tests, such as an electrocardiogram graph, a chest x-Ray, and a vital signs monitor's screen capture (Figure 9(b),(c),(d)). For each category selected, a pool of questions is displayed on the right side of the screen (Figure 9(a)). The interaction is similar to a text chat, where once a question is selected, the virtual patient responds accordingly. A "diagnose" button is provided at the top-left of the screen for when the student feels ready to elaborate a diagnosis. This button can be pressed at any time, so the student is free to skip any category or ask as many questions as needed before jumping to the diagnosis section, with the caveat of doing so within the six-minute time limit. Otherwise, the interview ends automatically, and a dialog box warns the student that the time limit has been reached and that a diagnosis needs to be given.

In the diagnosis section (Figure 10(a)), the student types the diagnosis and observations about the case. Next, on the prescription section (Figure 10(c)), a list of 36 drugs (corresponding to drugs available in a crash cart) is displayed in alphabetical order. The student can select any number of drugs from the list and type the dose and frequency, using the provided text boxes. Once finished, the student can press the "release patient" button at the bottom of the screen.

Once a station is completed, the application displays the performance score and the time used for the station (Figure 10(d)). The score is determined by comparing the flow of decisions against a pre-determined ideal reasoning model. This model is determined by the examiner or instructor when a station is designed.

The next screen shows a visualization of the performance along with textual feedback (Figure 10(e)). A summary of performance of the station is provided by pressing the clipboard icon at the bottom of the screen (Figure 10(f)). Finally, going back to the home screen the next station can be chosen and the process is repeated.

All the activity of the student while performing a station, such as the questions chosen, their sequence, and timestamp, is recorded by the application and logged as a TXT file format. This file is used by the external web interfaces (dashboard and back-end module) as a database to visualize results in different levels: per student, per station, per class, along a time period, among others.

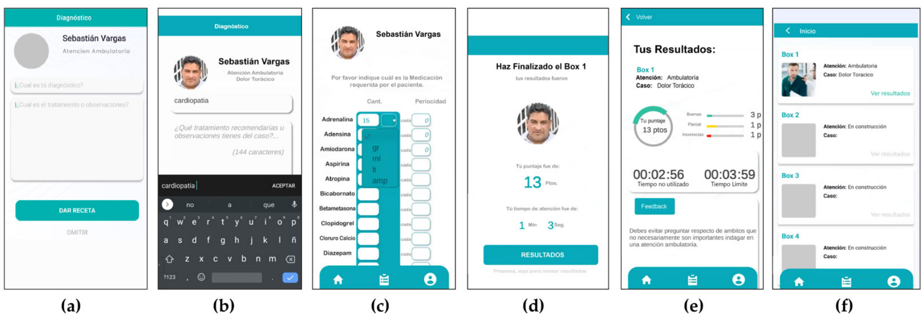

Fig. 10. (a) Diagnosis-treatment screen; (b) Diagnosis-treatment screen while text is being typed; (c) Prescription screen with pop-up for units; (d) Performance score screen; (e) Feedback screen; (f) Summary of stations

4.3 Application test

All participants reported previous experience applying traditional OSCEs. Their self-report yielded a mean level of 5 within a range of 1–7 (1=novice;7=expert). None of them had previous experience with eOSCEs. Their responses in regard of the application evaluation are illustrated in Table 1. All participants responded that the application was fairly easy to use (median score=3). The time allocated in the application to elaborate on each question was considered adequate by the respondents (median score=5). They also agreed that the application adequately represented a clinical reasoning process associated with a chest pain case (median score=5) and that it adequately depicted a primary care session of the Chilean healthcare system (median score=5). Finally, when asked about the quality of feedback given by the application, they all agreed that it was highly useful and pertinent (median score=5).

The experts responded to the open-ended questions and declared several positive and negative opinions of its design, usability, and offered suggestions for future iterations. A summary of their responses is presented in Table 2. In summary, their positive comments suggest that the MVP was perceived as a promising solution for a context-specific eOSCE and that it adequately assessed clinical reasoning. Negative comments were mostly within the expectations considering the preliminary stage of development.

In the questionnaire and during the interviews, the experts provided open-ended suggestions that are summarized in Table 3. In general, their suggestions covered UI aspects of the interface and were coherent with the preliminary stage of development of the MVP.

Table 1. Questionnaire results. Experts (n=3) scored each statement using a 1–5 Likert scale (1=strongly disagree, 5=strongly agree)

Statement	Median	Mean ± SD
The app is easy to use and navigate	3.0	3.0 ± 0.00
The time assigned to each question is adequate	5.0	4.7 ± 0.58
The app adequately represents a process of clinical reasoning associated with a chest pain case	5.0	5.0 ± 0.00
The app adequately depicts a primary care session of the Chilean healthcare system	5.0	4.7 ± 0.58
The feedback given by the app is useful and pertinent for the student	5.0	4.7 ± 0.58

Table 2. Summary of experts' (n=3) open-ended comments following each statement, categorized into common themes

Theme	Positive	Negative
Ease of use	Understandable and fast.	Unclear which icons functioned as buttons. Difficult to understand some instructions. I had difficulty in following the steps and general flow. Lack of a "back" button.
Visual Design	Everything is adequate (even for us shortsighted). Visual design is adequate.	The text boxes are too small, it should allow for more characters. Some menus are too close to each other, which leads to press the wrong button.
Time assigned to each question	Very adequate for an experienced professional. Sufficient for patient evaluation.	For undergraduate it may be little. Depends on the experience of the person who answers.
Representation of clinical reasoning	Clear, without confusion, and easy to understand.	Follows a consistent line of thought. I would change the phrase "discharge patient", because there's still more work to do even after the initial interview with the patient.
Depiction of local reality	It helped a lot that the patient [photo] looks Chilean. It represents care at the primary care level.	
Feedback given by the app	Feedback is consistent with the work done. Accurate, not confusing and applicable in the future.	
Was there anything that confused you while using the app?	Nothing.	Yes, the instructions: it was not clear that I should select the possible responses that seemed pertinent to me. Not being able to go back.
Was the tutorial sufficient to understand how the app works?	Yes, enough to understand. Yes, absolutely.	No, the instructions were not quite clear.

Table 3. Summary of experts' (n=3) suggestions from the questionnaire and the post-interview

Theme	Suggestion
Visual & interface design	Add a "back" button. Include a progress bar. Reposition elements: menus positioned on the top area, main list at the left, questions at the center, and the patient's answers on the right side. Make sure menus and buttons are not too close to avoid click mistakes.
Clinical reasoning	Include more options of possible questions and tests, if not you are making it too easy for the student. Include more options of possible treatments.
Depiction of local reality	The patient could use more colloquial language. Enhance the language of the patient.
Feedback	Include more detail, e.g. specify which questions were not used.
Tutorial	Improve the instructions given at the beginning of the test.
Other comments	For the prescription, use "unit of measure" instead of "amount". Include lab tests.

5 Discussion

5.1 Limitations

The project presented in this article is an initial proof of concept for a technological system that responds to a more efficient and cost-effective OSCE implementation in Chile. The software development was mainly focused on the implementation of the mobile application prototype. The dashboard and back-end module were developed at a conceptual level and with initial development, thus are not discussed in detail in this article.

Testing results are limited to a small group of experts in Chile and their perception of the interface from a UX and UI standpoint, so they are preliminary and not statistically significant. In addition, the experts tested the interface intended for students, so the results reflect their perception as expert examiners, not as end-users. Nevertheless, the team sees the preliminary results as promising. Testing the interface with experts enabled the team to validate several design features and also to identify future improvements. It is unknown how the proposed Ch-eOSCE system will perform in comparison with traditional OSCE implementations. Further research is required to assess this relevant aspect. Similarly, more development is required to reach a state where the whole system can be validated on a wider scale, particularly among healthcare students in Chile.

The software developed in Unity 3D enabled the implementation of a semi-functional MVP with enough fidelity to perform initial testing with a small group. The prototype included one of eight OSCE stations, particularly a chest pain case. However, since the functional station can act as a model for the development of additional stations, more representative testing (e.g. with a large number of students) will be able to be performed once more stations are implemented in the future.

5.2 Future research

The Ch-eOSCE has the potential to become a valuable tool for healthcare education in Chile. However, more research is needed to adapt the system for the diverse cultural and sociological realities in the country. Due to its geography and socio-political configuration, Chile is a very diverse country. In the Chilean healthcare system, there are significant gaps between geographically-isolated and urban areas, between public and private healthcare centers, and between wealthier and poorer zones within cities. Counting with an eOSCE able to adapt and accurately represent these diverse realities although challenging, it could have an enormous impact on the preparedness of students to face the diversity of the Chilean healthcare system.

At the current state of development, some of the Ch-eOSCE system components were developed in greater depth while others were developed at a conceptual or low-fidelity level. However, this strategy revealed how a fully developed system would work and enabled the team to foresee future technical solutions. Such is the case of the data output from the mobile application that could be replaced by a direct upload to a cloud-based database, readily available for calls from the user dashboard and back-end module. A solution like this would open the possibility of integrating machine-learning algorithms that could adjust the student-patient interaction in real-time based on the student's performance, thus opening the possibility of a deeper personalized experience.

6 Conclusion

Ch-eOSCE is a first step in the development of interactive OSCE technologies tailored for the Chilean healthcare context. Ch-eOSCE differs from other eOSCE applications by focusing on a credible representation of the local culture. Hence, it emulates the dialogues and idioms used by patients, it is consistent with the educational standards of medical schools in Chile, and considers the locally available treatments and procedures that the student would commonly face when working in the Chilean healthcare system. Ultimately, Ch-eOSCE helps the student to develop clinical reasoning skills in coherence with the local context. Currently available software in the market does not offer adaptation capabilities, forcing educators and students to adjust to foreign terminology, archetypes, and procedures, ultimately impacting the quality of the training and examination. In that sense, Ch-eOSCE has the potential to become a valuable tool for the education of future health professionals in Chile.

Ch-eOSCE aims to respond to the needs of students, examiners, and instructors for a more efficient, cost-effective, and easily-available OSCE system. For the student, it provides a tool that fosters a more frequent and easy way of training their clinical reasoning skills. For examiners, the system provides a more efficient way of evaluating students' performance in an OSCE. For instructors, the system provides tools for analysis and visualization of performance data in several dimensions, which can lead to constructive feedback and to informed academic decisions. Finally, for institutions, Ch-eOSCE has the potential to lower the associated costs of implementing traditional OSCEs.

Preliminary expert feedback suggests that the developed MVP was capable of emulating the clinical reasoning processes that take place in a traditional OSCE, and that the sample station developed adequately depicted an archetypical case of a Chilean patient attending a primary care facility. Developing one station for the initial prototype served to gain knowledge and make decisions about its design and features. The aim is to develop the remaining stations to obtain a fully functional prototype that can be tested on a larger scale.

This project contributes to the use of local talent to face the demands of digital technologies needed for the Chilean context. Having a team comprised of local designers, developers, and healthcare professionals, enabled a natural approach to consider the nuances of local culture, language, idiosyncrasy, and methods used in the Chilean healthcare system.

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