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A Simulation System for Medical Students to Improve the Learning Process in Madagascar - SESAM Project

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Abstract

SESAM is a three-year project initiated at the end of 2024, aimed at contributing providing stable support for medical training for students and local healthcare personnel in Madagascar, exploiting medical simulation techniques and implementing an open, flexible, and internet-independent e-learning system. The general objective is to improve the integration between medical simulation tools, the IT platform for delivering theoretical courses and the creation of content, even independently. Developed in collaboration with the University of Genoa (UNIGE), University of Antsiranana (UNA), Rotary, and the NGO NEXT, the project employs advanced simulation and interactive teaching technologies. Initially, the system will be installed at the University of Genoa's Simav Simulation Centre for training a few technicians and professors from UNA and Le Polyclinique Universitaire NEXT, a hospital in Antsiranana run by NEXT. Subsequently, the system will be shipped and installed in the hospital. The system includes medical manikin, LAN capability, video recording and editing facilities. Each student can interact directly or via a PC, autonomously or under the supervision of a medical teacher. Additionally, medical students will have access to digital documentation and interactive learning modules using PCs and network capabilities provided by this project.

Keywords: medical simulation; training; e-learning; open source

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1. Introduction

In recent decades, medical simulation has emerged as a fundamental educational technique in clinical training, offering controlled and safe environments where students and healthcare professionals can practice, learn, and improve their skills without posing risks to patients. Scientific literature highlights that simulation is not merely an educational methodology, but an ethical imperative to ensure patient safety and the quality of care [1], [2]. Recent studies have demonstrated the effectiveness of technology-supported simulated environments in fostering critical thinking, interprofessional collaboration, and deliberate practice [3], [4], [5].

In this context, the SESAM project aims to develop a training system based on medical simulation and flexible educational platforms, with particular attention to accessibility in low-connectivity settings such as Madagascar. The objective is to contribute to the dissemination of innovative, scalable, and sustainable educational models capable of addressing both local and global needs in healthcare training. The training of new generations is significantly delayed and faces various limitations.

The socio-economic and healthcare education situation in Madagascar needs improvement [6]. The training of new generations is significantly delayed and faces various limitations. This project focuses on the Antsiranana area in northern Madagascar, where the necessary healthcare and organizational prerequisites are critical. The project aims to contribute to the training of students in the medical field using new methods and technologies to promote more widespread and accessible knowledge. The infrastructure created by the project, initially oriented towards the medical sector, can be easily extended to remote learning in other fields as well, since based on open-source software no software fees are required. The project involves strong interaction among different entities and partners, including the University of Antsiranana (UNA), the University Hospital/Polyclinic managed by the NGO NEXT, the University of Genoa, particularly the Medical-Pharmaceutical School, the Simav Simulation Centre and Rotary International.

2. State of the art - Local Hospital and University

Le Polyclinique Universitaire Hospital in Antsiranana, managed by the NGO NEXT, is the main training site for theoretical and practical teaching for medical and surgery students, as well as the internship site for new graduates. Despite being the most efficient hospital in northern Madagascar, the academic training facilities are inadequate. The hospital includes a diagnostic center with a laboratory and radiology, 120 beds, an emergency room, general surgery, internal medicine, maternity, pharmacy, dialysis center, emergency laboratory, dental and ophthalmology clinics, two sterilized operating rooms, an intensive care unit, and a university teaching facility with changing rooms and bathrooms for students and interns, a meeting room, a teaching office, and classrooms. The hospital has internet access with WiFi and electricity, though connectivity is expensive and not guaranteed, and the library is poorly equipped. The medical and surgery degree course at UNA University of Antsiranana has a limited number of 25 students per year, totaling 150 for the entire degree course, which is adequate for the project. Newly graduated medical interns could also benefit from specialized training and information through the e-learning and simulation system addressed in the project. Currently, teaching methods at UNA's educational facilities are traditional, with teachers speaking and students taking notes. The SESAM project will significantly improve educational outcomes by enabling distance learning, simulation, and recorded medical training and documentation. The project is supported by the local Ministry of Education and Health.

3. Materials and Methods

Rotary International has promoted the project through its professional skills in IT, telecommunications, and teaching, particularly in Medicine-Surgery. Locally, Rotary will monitor the project's progress and logistics. The University of Genoa (UNIGE) will oversee the development and installation of the system in Genoa and the training of personnel who will come to Genoa for training. After these phases, the system will be shipped to Antsiranana. Additional UNIGE personnel will be involved in the on-site trial period to enhance knowledge and use of the system and methodologies. Remote assistance is also planned, depending on internet availability.

3.1. Simulation and Medical training plan

The training will be conducted within the professional disciplines of the medical and nursing degree courses, particularly in semiotics and clinical methodology and the professional medical-surgical internship. Cost and educationally effective manikin for clinical training will be used to skills from basic patient care to advanced nursing necessary for in-hospital patient care, i.e. Lardal clinical trainer 'NursingAnne' (https://laerdal.com/us/products/simulation-training/nursing/nursing-anne). This flexible manikin platform allows multiple accessory modules to be added including trauma, NBC module, and bleeding control for use in multiple settings. UNA teachers will be able to use interactive clinical cases dedicated to medical and nursing students provided by the University of Genoa and created by them after receiving training from the technicians and teachers at the University of Genoa participating in this project. Students will also be able to practice on-site using innovative simulation methods to learn both technical (macrosimulation using a manikin) and relational (role-playing) skills. Learning assessment will be conducted using the Objective Structured Clinical Examination method [7], [8]. UNA teachers will be trained to use these methods during the training period in Genoa and by on-site volunteers. The clinical cases provided by the University of Genoa have been created (as examples of interactive teaching) in Italian and English, known by many students attending the hospital where many operators speak Italian.

3.2. Involved Information and communications technologies

Access to the online course system in the cloud provided free of charge by the University of Genoa requires guaranteed and constant quality internet access, which is not feasible at the destination site at reduced costs and with continuity due to the limited availability of the internet network. At the same time, the specialized content of the courses is often updated annually. By making a copy of the course distribution system adopted by the University of Genoa and the courses of interest, continuous data exchange is not necessary for the system to function. It is therefore convenient to create a local copy of the system and the UNIGE courses so that they are always accessible at reduced costs. The courses will be updated periodically at the most favorable times, and maintenance can also be done remotely. Local personnel will still be trained in basic operations for their maintenance. The courses will be updated as needed. The implementation of the local system also involves creating a local network with a server and medium-sized storage, a router for connectivity when needed for updates and videoconferencing, and PCs on the local network to access the course content stored on the local server. This approach improves educational systems for local students because it will allow them to access courses and prepare, even in the absence of internet connectivity, at any time and without the physical presence of the teacher. The system's power consumption is relatively low (a few hundred watts) and depends on the intensity of use. Electrical continuity is guaranteed by its own UPS system to avoid accidental damage, and the Polyclinic has autonomous power generation groups, also necessary for medical and surgical practices.

3.3. Moodle E-Learning Platform

The course storage system is the worldwide adopted open-source platform 'Moodle' (https://docs.moodle.org/dev/Moodle_architecture). The Moodle platform provides teachers with a teaching tool to be used in conjunction with other distance learning solutions and according to specific needs. Any content can be uploaded to the platform, including common UNIGE teachings and clinical cases in various disciplinary fields, such as Internal Medicine, Surgery, General Medicine, and Nursing. The solution allows for complete tracking of teaching activities and can be integrated into multiple training paths flexibly and efficiently. The system is compatible with all IT devices (smartphones, tablets, computers). Various types of interactive assessment tests can be defined within the platform. Detailed reports can be created, conducting in-depth statistical analyses, and clinical cases can be integrated into existing FAD courses. Moodle also supports the SCORM (Shareable Content Object Reference Model) format, making it possible to import courses created on other available Learning Management System (LMS) platforms.

4. Results and Discussion

4.1. Examples of Educational Use

The LMS can be used in multiple training scenarios; for example, we can cite the following two types:

- Self-Learning Activities: Students connect to the LMS platform and use the teaching content autonomously; the system records the teaching activities, verifying the correct execution of the same activities.
- Teacher-Guided Activities: The teacher in the classroom or during a webinar presents the content, commenting on clinical data, comparing students' decisions with the evidence from the literature and the guidelines of scientific societies. It is also possible to adopt the Blended Learning mode where students carry out the planned teaching tasks autonomously; subsequently, the teacher in the classroom or during webinar comment on the results, discussing the students' interaction statistics.

4.2. Simulation for Practical Skills Acquisition

For the acquisition of practical skills, simulation will be used. The teaching methodology refers to Kolb's "learning by doing" model [9], [10], which involves in loop steps: ACTION -> EXPERIENCE -> OBSERVATION -> REASONING -> RE-ACTION. Learning occurs in phases:

- Motivation: It is important that the learner feels the importance of the competence to be acquired for their future clinical activity, either due to its prevalence or, conversely, due to the improbability of acquiring it in a clinical environment or, finally, due to the risk of performing it for the first time on a patient.
- Observation: The learner observes the teacher performing the standard procedure, also by using TVCC for recording both training and practical on-site procedures.
- Reflection/Abstract Conceptualization: The learner is invited to reflect on what has been observed and organize it conceptually. In this phase, an effective tool is the construction of a checklist.
- Execution of the Gesture: The learners take turns, referring to the checklist, performing the gesture on the simulator.
- Feedback: The teacher provides focused and corrective feedback at the end of each execution.
- Acquisition of Autonomy: Once feedback is obtained, the learner must have the opportunity to practice until they feel sufficiently confident to perform the gesture autonomously. For the acquisition of relational skills, the role-playing teaching methodology will be used, which follows well-defined implementation phases.
- Definition of Educational Objectives: It is essential that this training moment is included in the context of the learners' curriculum to complement other teaching methods and clinical experience, which should never be replaced.
- Preparation of the Script: For the execution of the role-playing game, the teacher prepares a "script" that reproduces the relational situation to be addressed.
- Conducting the Simulation: The protagonists, based on the mandate received, behave "as if," for a scenario that usually lasts about ten minutes.
- Debriefing: The debriefing is a fundamental moment in the learning process, and its implementation involves predefined phases, involving both the teachers and the students. Questionnaires will be prepared and distributed to the students during the different stages of the project. These questionnaires will be then collected and analysed, and the results will be presented in this debriefing phase.

4.3. Project Implementation phases

The project will be implemented over three years, starting from month 10/2024 with activities including needs analysis, evaluation of local IT and teaching experience, design of blended e-learning courses, procurement of equipment, training, shipping, installation, testing, pilot module development, surveys, system updates, field tests, and sustainability planning. Consequent timeline is listed in Table 1.

Table 1. Implementation phases.

#	Activity	Duration [months]
1.	Needs analysis at UNA University	3
2.	Evaluation of local IT and teaching experience	3
3.	Design of blended e-learning courses	6
4.	Procurement of IT and multimedia equipment	4
5.	Technical operator training (VTT)	1
6.	Medical and multimedia personnel training (VTT)	1
7.	Shipping, installation, and testing on-site	5
8.	Pilot module development and validation	12
9.	Surveys and user feedback	6
10.	System updates and remote support setup	8
11.	Field tests and evaluation	5
12.	Sustainability planning beyond 3 years	4
13.	Results presentation to local authorities	2

4.4. Impact Measurement

Key performance indicators (KPIs) include the number of trained professionals, student platform access, teaching hours used, exams taken, teaching material produced, and evaluation survey responses. KPI are listed in Table 2.

Table 2. KPI.

#	Measure	Collection method	Frequency	Beneficiaries
1.	Trained professionals	Direct observation	Quarterly	1–19
2.	Student platform access	Direct observation	Quarterly	100–499
3.	Teaching hours used/year	Direct observation	Annually	100–499
4.	Exams taken using e-learning content	Direct observation	Annually	100–499
5.	Hours of teaching material produced	Direct observation	Annually	1–19
6.	Evaluation survey responses	Direct observation	Annually	100–499

5. Conclusion

The SESAM project aims to professionally train university teachers of the Faculty of Medicine and Surgery at UNA University of Antsiranana in Madagascar so that they can create simulation teaching modules for students, usable on an e-learning platform and on specific intranets. The creation of an e-learning teaching system. This system will be installed at the hospital; technicians will be trained to manage it. Compatible with often discontinuous internet connections, remote support for the system from Italy is also planned. Training can thus take place not only in the presence of the teacher but also in a delayed and remote mode by accessing the installed system. In addition to direct training for medical students, training opportunities will also be created for support healthcare personnel.

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