

AN OPEN-SOURCE BMET LIBRARY: RESULTS ON ACCESS AND VALUE

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Abstract

A barrier to keeping medical equipment in service in low resource settings is access to knowledge on how to maintain and repair medical equipment. In order to address this barrier, Engineering World Health and Robert Malkin's Developing World Healthcare Technologies Lab (DHT) at Duke University have created a digital library of open source materials. The library contains information on anatomy and physiology, basic technician skills, electronics, Healthcare Technology Management, and mathematics. The library uses Google translate to provide the material in multiple languages. To understand if the library is useful to technicians in a variety of contexts the DHTLab undertook a pilot study with technicians and engineers from Uganda, Cambodia, Kenya, France, and Honduras. The pilot aims to gather data on two main areas: the usability and utility of the library.

1 Introduction

A lack of trained biomedical engineers and biomedical technicians is a challenge in low resource settings across the globe. Eighty-five percent of African hospitals surveyed reported difficulty in finding qualified engineers locally. Seventy-three percent also reported difficulty finding qualified biomedical technicians. Similarly, a shortage of trained biomedical engineers and technicians affects Latin America and Asia [1].

Having trained biomedical engineers and technicians is essential to ensuring equipment in hospitals can be properly maintained. Research has shown dramatic reductions in the lifespan of equipment when no support exists for proper use and maintenance. Issakov found improper maintenance and use of medical equipment decreased the lifespan by 30 to 80% [2].

Insufficient access to knowledge for completing repairs and maintenance for medical equipment creates difficulties for technicians in low resource settings. Degree programs or training opportunities for biomedical engineers or technicians are rarely available in many low resource countries. Books on biomedical engineering are often expensive, entirely

unavailable, or not translated into a language useful to the technicians. Available resources are often outdated and poorly organized. Service and user manuals are scarce in hospitals. Technicians routinely identify this lack of knowledge as a barrier to repair. Untrained technicians in Rwanda and Honduras reported a lack of knowledge as an obstacle to repair for 19% of out of service and partially functional equipment [3].

In order to address this barrier, Engineering World Health (EWH) and Robert Malkin's Developing World Healthcare Technologies Lab (DHT) at Duke University have created a digital library of open source materials useful for equipment repair. The goal of this library is to make the required knowledge more readily available to technicians practicing in clinical environments, as well as to instructors and students of biomedical maintenance and management.

2 The library

The library (<http://library.ewh.org>) contains information on anatomy and physiology, basic technician skills, electronics, Healthcare Technology Management, mathematics, and resources on the maintenance and repair of medical equipment. The library is sufficient to cover all the topics typically found in Biomedical Technician training programs. It comprises the largest part of the curriculum EWH uses in training programs in both Rwanda and Cambodia. EWH created the library using Greenstone, an open source tool for building and distributing digital library collections. Greenstone has been used to create large, searchable collections of digital documents and to organize metadata about the documents. The library has a search function, which allows for searching titles and within documents

The library offers unique components such as the materials on basic technician skills created by the DHTLab, which we call the Biomedical Technician's Assistant (BTA) Skills. The DHTLab created the BTA Skills as a core set of the most basic and useful competencies needed to fix equipment in low resource settings [4]. In order to do this, the DHTLab analysed 2,849 equipment repair requests from sixty low resource hospitals in eleven nations in Africa, Europe, Asia, and Central America. An engineer or engineering student analysed each piece of equipment and attempted a repair using only locally available material. The BTA Skills span six domains of

knowledge specifically, electrical, mechanical, power supply, plumbing, motors, and installation or user training. The results of this analysis showed 66% of out of service equipment could be placed back into service with only 107 basic skills [4].

Another unique resource is *Medical Instrumentation for the Developing World*, a book written by the faculty and students of EWH Summer Institute and other engineers who have worked in low resource settings. The book is divided into chapters, each dealing with an individual piece of equipment. The chapters are organized by sections into equipment usually found in the operating room, emergency room, and intensive care unit and equipment found in the clinical laboratory. Information on troubleshooting and testing equipment before returning it to use in low resource settings is covered in the text.

The library also contains the WHO's *How to Manage Series for Healthcare Technology*. These guides on how to manage and plan for healthcare technology were produced by consultants and advisers from many organizations with extensive experience working in low resource settings [5].

Several textbooks on foundational subjects for working with medical equipment are included in the library. Anatomy and physiology resources focus on the parts, systems, and functions of the human body. Mathematics resources cover algebra, geometry, statistics, and trigonometry.

3 Results

EWH set up programs for improvement in biomedical capacity in Ghana, Rwanda, Honduras, and Cambodia. Trained technicians in Rwanda and Honduras cited a lack of knowledge as a reason they were unable to complete a repair only 5% of the time as compared to untrained technicians 19%, a significant decrease, $p < .001$ [3]. In Rwanda, we conducted an assessment in twenty hospitals and found impressive effects on the amount of equipment out of service. Hospitals with Rwandan technicians trained using this curriculum, have almost half as much out of service equipment, 10% vs 18% ($p < .01$). Trained technicians also reported using the BTA Skills significantly more than non-trained technicians, $p < .05$ [6].

3.1 Usability and utility of the library

We sought to determine how useful and usable the library would be to technicians in low resource settings. We piloted the library with eight biomedical technicians in Uganda, Kenya, and Honduras. All the technicians had completed high school and technical school, and three had college degrees. The characteristics of the technicians are summarized in Table 1.

Technician	Country	Self-rated English Proficiency (1-10 scale)	Years Fixing Medical Equipment
1	Uganda	8	3
2	Kenya	9	17
3	Honduras	5	23
4	Kenya	10	7
5	Honduras	4	23
6	Honduras	8	12
7	Uganda	10	12
8	Kenya	10	6

Table 1: Overview of technician characteristics

Technicians were asked to complete two tasks involving locating and reporting on information contained in the library in English and then provided feedback about the organization, usefulness, and usability of the website. The internet speed for these technicians did not represent a significant barrier. Downloading the PDF version of most files took an average of eight seconds. Five of the eight technicians had access to the internet at work.

Most technicians (7 of 8) found it very easy to find information about equipment of interest. However, some technicians (3 of 8) had difficulty using the search function because searching phrases did not produce the desired result. Technicians with less English proficiency reported more difficulty in locating and understanding documents. Half of the technicians reported they would be more willing to use the website if the documents and search functionality were available in their native language.

Technicians also reported on how useful the library and specific subjects would be for their jobs. Two technicians reported that the library would be always useful for their jobs, four reported it would be often useful, and two stated it would be sometimes useful. The breakdown of response by specific subject area is summarized in Table 2.

Topic	Usefulness Ratings				
	Very High	High	Neutral	Low	Very Low
Equipment Repair	1	3	4	0	0
Healthcare Technology Management	3	3	2	0	0
Math	1	5	2	0	0
Physiology	3	5	0	0	0
Electronics	1	5	1	1	0

Table 2: Ratings of subject usefulness

Overall, most technicians reported they would use this website a few times a week. Technicians described that the library would be useful in nurse and student training, hospital management, career development, knowledge and skill acquisition, maintenance, repairs, and troubleshooting.

3.2 Quality of Google Translate for French, Spanish, and Khmer

To determine the quality of the translation provided by Google, we conducted a pilot study of the library with twelve respondents. Respondents provided feedback on the quality of the translation, the degree to which the translation was a barrier to using the website, and the percentage of information that was unintelligible due to errors in the translation.

Spanish technicians (2 of 4) rated the translation as very high quality. Estimates of the percentage of unintelligible information due to errors in the translation ranged from zero to thirty percent.

Khmer speakers (2 of 4) rated the translation quality as poor. All respondents agreed the translation was a barrier in using the website. Thirty to fifty percent of the information could not be understood due to errors in translation. Khmer technicians reported a large number of words and phrases were out of order or meaningless.

The French respondents' estimates of the translation's quality had the most variability. Two respondents rated the translation as good, one medium, and one poor. They estimated between ten and sixty percent of the information was incomprehensible due to errors in the translation. French respondents reported the non-technical portions of the website were more accurately translated than the technical phrases.

4 Conclusions

To our knowledge, this is the first comprehensive library openly available to biomedical technicians anywhere in the world. While the translation is rudimentary, it is available in 80 languages.

Overall, the pilot revealed technicians found the library useful. Technicians reported being able to find desired resources and that the library contained information they would use several times per week.

The pilot revealed the current limitations of the translation. However, as Google translate is continually improved and expanded, the quality and reach of the library will also increase.

However, the library has limitations that improved translation will not mitigate. Technicians requested better search capabilities, videos and interactive content, and forum capabilities from the library. Despite these limitations, this pilot confirms that the library is a first step in decreasing the barrier of access to knowledge on maintaining and repairing biomedical equipment for technicians in low resource settings.

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