Three-dimensional modeling of a primary health care clinic in Ho, Ghana: its contribution to student engagement, fundraising, and program planning

Lalith Polepeddi¹ and Elizabeth Barden²*

¹Departments of Biology, Electrical Engineering and Computer Science, Northwestern University, Evanston, IL, USA; ²Global Health Studies Program, Northwestern University, Evanston, IL, USA

Improvements in computer-based technologies can be leveraged to enhance engagement of remote stakeholders with the health needs of a geographically distant community. Three-dimensional (3D) modeling offers a platform to create detailed spatial representations through which stakeholders can experience improvements in shared understanding as well as increased involvement in community health projects occurring anywhere in the world. This case study describes the development of a 3D model of a community health clinic in rural Ghana used to encourage fundraising and sustain global engagement among students at Northwestern University. The resulting ‘virtual clinic’ was achieved quickly and at little cost, suggesting a broader utility of 3D modeling for global health practitioners for increasing donor engagement and resource mapping.

Keywords: 3d visualization; 3d modeling; virtual mobility; geospatial modeling; Google Earth; Google Sketchup; Ghana; community health center

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This paper describes the development of a 3D representation of the Health Outreach and Peer Education (H.O.P.E.) Centre, a community health clinic in Ho, Ghana, and its current uses at Northwestern University (NU). This ‘virtual clinic’ was created to develop the potential for NU students to participate in international service learning as remote visitors by virtually negotiating the Center as it appears in actuality. Current applications of computing resources in the health arena primarily have focused on direct patient care, such as electronic medical record systems (1), decision support, and disease surveillance systems (2, 3). However, leveraging this technology to enhance global engagement in promoting health at the community level has not been fully explored, despite significant potential benefits.

Computer technology can effectively collapse physical distance by enabling asynchronous communication and decentralized participation (4). Virtual environments can facilitate better perception and shared understanding among local decision makers and remote stakeholders of the spatial relationships, salient environmental features including geographic barriers, and facilities layout of the focal health center. Although commercially available modeling products and support can be purchased, the availability of free, sophisticated three-dimensional (3D) modeling software (5, 6) allows for the rapid creation of virtual environments at no direct cost, which tremendously increases its appeal to global health practitioners working in resource poor settings.

Virtual environments are currently utilized for diverse purposes, notably to enhance productivity during the design and construction of buildings. Spatial visualization prevents errors and loss of information throughout workflow and across multiple collaborators (7). A prominent application of 3D modeling is for urban planning and emergency response. Virtual reconstruction of entire cities are useful to engage the community in public planning, attract businesses by enabling employers to visualize strategic advantages of a site, and digitally preserve historic areas (8, 9). This technology also is useful for effective and timely decision support for communities in the face of emergencies, such as wars, epidemics, and natural disasters (10–12).
Furthermore, 3D modeling of internal spaces can be achieved. Being able to visualize not only the building’s exterior but also the intricacies of the building’s interior, including such basic factors as the availability of seating and storage, the presence or absence of refrigeration, and the placement of ramps, restrooms, and waiting areas, prevents erroneous assumptions about facility capacity for remote users, such as external donors or program planners.

It is our view that 3D modeling has applications in international health that have not fully been realized, and that current applications of modeling can be easily expanded to realize this potential. We believe spatial visualization can enable partners across the globe to initiate and maintain involvement with community health projects and enhance the likelihood of their participation in future program development.

**Case study: development of an interactive 3D model of a community health center**

The virtual clinic developed in this project was intended to be a symbol of achievement and an impetus for fundraising and sustaining global engagement among GlobeMed students at NU. GlobeMed is a national organization of student-led chapters working together to advance a movement for global health equity and social justice (14). GlobeMed provides a cocurricular experience for students to work in partnership with grassroots health organizations to improve the health of the impoverished around the world; each university’s chapter develops a relationship and agenda with a unique community. The modeling project described was undertaken by the sitting president of the NU chapter (LP).

Since 2006, GlobeMed-affiliated students at NU have helped to fund the construction and expansion of services and facilities at the H.O.P.E. Centre. In collaboration with the Ghana Health Service (GHS), GlobeMed at NU students have maintained involvement with the Center in fulfilling its mission to deliver essential health services to eight rural communities in the Volta region. The Center places emphasis on preventive medicine by holding child welfare clinics and sexual health seminars. These types of community health programs have increased the Center’s visibility, and the number of clients served since the Center’s opening has increased fourfold, from 85 clients in 2007 to 403 in 2009. To expand the Center’s resources, in 2008 GlobeMed at NU supported the development of a diagnostic laboratory.

While the fundraising efforts of GlobeMed at NU students have directly expanded facilities and services at the H.O.P.E. Centre, the inherently limited accessibility of this international collaboration has led to a visual disconnect among students. In the past 3 years, of nearly 100 GlobeMed students at NU, only nine have had the opportunity to physically travel to Ghana. For the remainder, project updates received via e-mail have been useful to document the rationale for fundraising campaigns, but they do not offer context or convey immediacy since most students cannot physically observe where and how projects are implemented.

In constructing a virtual representation of the H.O.P.E. Centre, the lead author (LP) intended to extend accessibility by supplementing project reports with 3D visualizations. The virtual clinic allows any number of students at any time to ‘visit’ the clinic and negotiate its space for program planning purposes or for site familiarization without incurring economic and temporal costs of travel, imposing a burden on clinic staff, or intruding on patient privacy.

Polepeddi worked at the H.O.P.E. Centre from 12 August 2009 to 10 September 2009. In 10 days, he generated a 3D model of the Center according to the following process (depicted as a pipeline in Fig. 1). First, dimensions of the exterior elevations and interior rooms of the H.O.P.E. Centre were recorded to the nearest inch using a ruler and a digital tape measure. Measurements and locations of furniture and appliances also were recorded. Video recordings and photographs of the space during routine use were captured using a digital camcorder (Flip Video, Cisco Systems). Next, physical dimensions were translated into Google SketchUp, a 3D modeling software freely available online from Google, Inc. (5). Google SketchUp allows simple two-dimensional shapes to be extruded into 3D buildings. Alternately, users can download completed 3D models from a searchable online repository (13). In this case, a 3D representation of the H.O.P.E. Centre was created from actual measurements. Fig. 2 depicts an exterior view of the virtual clinic created using Google SketchUp in comparison to a photograph of the actual brick-and-mortar clinic.

**Fig. 1.** 3D modeling pipeline. Physical measurements of the H.O.P.E. Centre were used to digitally construct a 3D representation. The completed 3D model was virtually placed in the H.O.P.E. Centre’s actual environment.
Third, the completed 3D model was uploaded to Google Earth, a freely available geographic navigation application from Google, Inc. (6), which enables users to view satellite imagery of Earth. The 3D model was placed on the H.O.P.E. Centre’s actual geographic coordinates, integrating the model into its virtual environment. Therefore, surrounding natural features (such as fields and topography) as well as manmade infrastructures (such as roads and surrounding houses) are clearly visible in the virtual representation.

Finally, an interactive web page of the virtual clinic was developed (see http://virtualclinicsite.org). The Web site allows visitors to view and explore the H.O.P.E. Centre through animations, videos, and an interactive 3D graphics application. Visitors take a virtual flight directly to the H.O.P.E. Centre, through the Google Earth interface. Narrated video tours integrate video footage from the actual Center with animations of the virtual clinic so visitors may understand how the space is organized and utilized by staff and their clientele on a routine basis (http://virtualclinicsite.org/guidedTours.html). Visitors also may explore the virtual clinic independently through the Google Sketchup interface (http://virtualclinicsite.org/freePlay.html).

The investment of time to measure physical dimensions is the primary cost in producing the model, as the software is available at no direct cost from Google, Inc. Using the online repository for shapes can save time creating interior objects, albeit with some loss of validity. Maintenance cost and upkeep of the Web site once created is negligible beyond the initial cost of obtaining the domain name.

### Conclusion

Since completion of the project, the virtual clinic has been widely utilized by GlobeMed at NU students to enhance project planning and fundraising. The virtual clinic has enhanced strategic planning for future facility development. GlobeMed students can virtually incorporate the space needs and likely behavior of the Center’s community into facility designs, such as larger rooms with additional seating to accommodate family members of clients, or space for food preparation and storage, where contextually relevant. In this way, all future infrastructure design optimizations can be made remotely and prior to construction.

An additional utility of the virtual clinic has been to facilitate transparency and emphasize the tangible impact of fundraising efforts. Using the virtual clinic, GlobeMed at NU students are able to virtually situate themselves at the H.O.P.E. Centre and observe how their fundraising efforts have directly expanded its infrastructure and services, most recently in the form of a diagnostic laboratory. This form of virtual accountability is useful for students to see how funds were utilized and encourage future participation.

3D visualization of community health resources offers significant financial, temporal, and conceptual incentives for public health practitioners. The benefits of 3D modeling for global health are far-reaching, especially for project planning and fundraising purposes. Furthermore, these benefits can be achieved quickly and at minimal cost, with nothing more than a ruler, graph paper, and a laptop computer.

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### References

1. Fraser HSF, Jazayeri D, Nevil P, Karacaoglu Y, Farmer PE, Lyon E, et al. An information system and medical record to support HIV treatment in rural Haiti. BMJ 2004; 329: 1142–6.
2. Centers for Disease Control and Prevention. National Electronic Disease Surveillance System. Available from: http://www.cdc.gov/ncidod/diseases/hivirus/ [cited 18 December 2009].
3. Google Flu Trends. Available from: http://www.google.org/flutrends/ [cited 19 December 2009].
4. Maru DS, Sharma A, Andrews J, Basu S, Thapa J, Oza S, et al. Global health delivery 2.0: using open-access technologies for transparency and operations research. PLoS Med 2009; 6: e1000158.

5. Google Inc. Google Sketchup (Version 7.1) [Software]; 2009. Available from: http://sketchup.google.com/ [cited 19 December 2009].

6. Google Inc. Google Earth (Version 5.0) [Software]; 2009. Available from: http://earth.google.com [cited 19 December 2009].

7. Bouchlaghem D, Shang H, Whyte J, Ganah A. Visualisation in architecture, engineering and construction (AEC). Automation Constr 2005; 14: 287-95.

8. Shiode N. 3D urban models: recent developments in the digital modelling of urban environments in three-dimensions. GeoJournal 2000; 52: 263-9.

9. Google Inc. Success stories: learn about how some local governments have used 3d and Google Earth to engage the public. Available from: http://sketchup.google.com/3dwh/citiesin3d/successstories.html [cited 19 December 2009].

10. Dutta-Bergman M, Madhavan K, Arns L. Responding to bio-terror: a strategic framework for crisis response pedagogy using 3D visualization. New York, NY: International Communication Association; 2009.

11. Zlatanova S, Holweg D, editors. 3D Geo-information in emergency response: a framework. Proceedings of the Fourth International Symposium on Mobile Mapping Technology, Kunming, China, 29–31 March 2004.

12. Kemec S, Ertugay K, Duzgun HS. Emergency state health service accessibility visualization in a 3D city environment. ISPRS, DGfK and ICA Joint Workshop “Visualization and Exploration of Geospatial Data,” University of Applied Sciences, Stuttgart, Germany, 27–29 June 2007.

13. Google Inc. Google 3D Warehouse. Available from: http://sketchup.google.com/3dwarehouse/ [cited 19 December 2009].

14. GlobeMed. Who we are. Available from: http://globemed.org/about/the-globemed-network [cited 31 July 2010].