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Improving Health with Science: Exploring Community-Driven Science Education in Kenya

A Dissertation submitted in partial satisfaction of the requirements for the degree Doctorate of Philosophy in Education

by

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DEDICATION

For Stephen and Peter, who will write the story of the future.

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ABSTRACT

Improving Health with Science: Exploring Community-Driven Science Education in Kenya

by

Anne Emerson Leak

This study examines the role of place-based science education in fostering student-driven health interventions. While literature shows the need to connect science with students' place and community, there is limited understanding of strategies for doing so. Making such connections is important for underrepresented students who tend to perceive learning science in school as disconnected to their experiences out of school (Aikenhead, Calabrese-Barton, & Chinn, 2006).

To better understand how students can learn to connect place and community with science and engineering practices in a village in Kenya, I worked with community leaders, teachers, and students to develop and study an education program (a school-based health club) with the goal of improving knowledge of health and sanitation in a Kenyan village. While students selected the health topics and problems they hoped to address through participating in the club, the topics were taught with a focus on providing opportunities for students to learn the practices of science and health applications of these practices. Students learned chemistry, physics, environmental science, and engineering to help them address the health problems they had identified in their community.

Surveys, student artifacts, ethnographic field notes, and interview data from six months of field research were used to examine the following questions: (1) In what ways were learning opportunities planned for using science and engineering practices to improve

community health? (2) In what ways did students apply science and engineering practices and knowledge learned from the health club in their school, homes, and community? and (3) What factors seemed to influence whether students applied or intended to apply what they learned in the health club? Drawing on place-based science education theory and community-engagement models of health, process and structural coding (Saldaña, 2013) were used to determine patterns in students' applications of their learning.

Students applied learning across health topics they identified as interesting and relevant to their community: hand-washing, disease-prevention, first aid, balanced diet, and water. Students' application of their learning was influenced by internal, external, and relational factors with the community, science education factors, and cultural factors. Some factors, which may have been barriers for students to apply their learning, were turned into supports via bridging strategies used by the students and teacher. Bridging strategies allowed students to connect between their place and science in meaningful ways in the classroom. These strategies were critical in bringing students' place into the classroom and enabling students to apply their learning toward place.

The model resulting from the identified factors informed existing models for sociocultural considerations in community-based health interventions. The community-engagement applied practices of science (CAPS) model serves to conceptualize findings in this study and informs an integrated method for using community-engagement education as a stimuli for students to become cultural brokers and improve community health. In addition to focusing on teaching practices of science and encouraging students to apply their learning, this research suggests that bridging strategies can be used to connect science with a students' place in meaningful ways that serve both students and their local communities.

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Figure 1. A health club student collects water near his home in Kenya.

Chapter 1: Introduction

1.1 Statement of the Problem

Health, water, and development are intrinsically linked; lack of clean water and adequate sanitation lead to child mortality from otherwise preventable diseases. Water is crucial for survival, yet about one third of the total population of Africa, around 300 million people, lack access to clean water (Braune & Xu, 2009). Climate change, drought, and limited access make water development and management projects crucial in the horn of eastern Africa. Furthermore, access to clean water can minimize the time people spend on collecting water everyday leading to economic advancements for women, increased school attendance for children. Most importantly, it can minimize the spread of disease and reduce local poverty (Harvey, 2008). Development projects, often started by foreign organizations, attempt to improve access to water; yet, these projects are not easily sustainable.

Communities lack the leadership, management, training, supplies, and understanding of proper usage to maintain and make the most of their watersheds and systems (Carter, Tyrrel, & Howsam, 2007). Education is a necessary and often overlooked component of these projects. Where there *is* education, it is often the male leaders in the community who are knowledge-holders; however, in most rural Kenyan communities, *women and children* fetch the water, do the wash, boil water for cooking, give water to the animals, and draw water for bathing (van Koppen, 2009). Science education that relates to clean water access and other local needs, provides a potential pathway toward community development that is both effective and sustainable.

Though science education has potential for improving community health, learning science in school is often perceived by students as disconnected from their experiences out of school (Jegede & Aikenhead, 1999; Lim & Calabrese-Barton, 2006). Although literature shows the need to connect science to students' local area so they can practice science that relates to and informs their community (Aikenhead, Calabrese-Barton, & Chinn, 2006), there is limited understanding of how to connect students' local place and community with science. This is especially true for underrepresented students and underserved communities who tend to perceive pronounced differences between their own cultures and western science (Aikenhead, 2006). While research studies have begun addressing this problem by developing new curricula and providing opportunities for students to work with locals in their community (Barnhardt, 2007; Lim & Calabrese-Barton, 2006), there are still limited resources that teachers and students can use to actively link across the cultural borders that divide their local place and school science.

Connecting the seemingly different life worlds of students' local place and school science can be beneficial for both students and their communities. Recent studies show that when students bring what they learn from their culture and community into the classroom, they are more motivated and interested in their learning (e.g., Keane, 2008; Venville et al., 2008). Furthermore, when students apply what they learn in the classroom to their home and community, both students and their community can be improved (e.g., Barnhardt, 2007; Bouillion & Gomez, 2001; Chinn, 2011). Integrating science education with place and community is especially vital for rural communities like those in Sub-Saharan Africa where science could lead to improvements in health, sanitation, and daily living (Panter-Brick, C., Clarke, S. E., Lomas, H., Pinder, M., & Lindsay, S. W., 2005). Existing health behavior change models provide support for community scale health education; however, they are limited in the ways they integrate science education practices and place-based science education approaches. Integrating science education with students' place into health behavior models has implications for how we address crucial problems facing underserved communities today, problems like access to clean water.

1.2 Personal Motivation

In the US, I worked with afterschool clubs and teachers to foster students' interest, persistence, and confidence in science in order to improve access to science education for underrepresented students. In an effort to understand access to science education on a community level and from different cultural perspectives, I began exploring science education in Sub-Saharan Africa. My prior research on access to science education for girls in West Sub-Saharan Africa and development work with Engineers without Borders in

Kenya fostered my interest in research that impacts both the field of education as well as sustainable development in health and engineering. Working with Engineers without Borders, I often saw a need for education to support engineering. For example, a water system that delivers filtered potable ground water through a tap can be re-contaminated from animals or poor practices of water usage, storage, and maintenance as is shown in Figure 2 below.

Figure 2. One of the engineering systems in Namerokamano being re-contaminated by a goat and a plastic-bottle funnel stored on the ground.

On one of my implementation trips with Engineers without Borders, we worked with leaders in the Kenyan village where this study took place. Those leaders highly valued education in their community and encouraged me to conduct research that would better integrate education with the development goals of our engineering projects as well as encourage their own young students to pursue careers in science. Their hope, like mine, was that sustainable development means that not only will engineering projects improve the community for many years to come, but that in time the students in their own community will become the scientists, engineers, and leaders of future development efforts.

1.3 Purpose of the Study

To better understand how students can learn to connect issues important to their place and community with practices of science in a village in Kenya, I worked with community leaders, teachers, and students to develop and study an education program, in the form of a health club, with the goal of improving knowledge of health and sanitation. While students selected the health topics they hoped to address through participating in the club, the topics were taught with a focus on providing opportunities for students to learn science and engineering practices and health applications of these practices. These practices were derived from the Next Generation Science Standards (NGSS Lead States, 2013) and the Kenya Syllabus (Kenya Literature Bureau, 2009), and provide opportunities for students to experience science as performance. Le Grange (2007) suggests that learning science as performance situates science in real word social contexts. With this in mind, students learned chemistry, physics, environmental science, and engineering to help them address the health problems they had identified in their community.

The purpose of this study was to contribute to developing a model of effective educational interventions that facilitate students in connecting science and engineering practices with their place. To do so, I strategically provided students with opportunities to learn science and engineering practices, helped students to make connections between these practices and their local community, and explored the specific opportunities afforded within these plans. Through this, I discovered the ways in which students applied what they learned toward improving health in their home and community and the factors that supported or interfered with students' ability and desire to do so. Understanding the context and factors for connecting place with science and engineering practices will likely impact the ways in which science educators support students who may face barriers between their place and school science. In addition, this research can guide education and development planning by suggesting contextual and classroom-based factors that influence students' likelihood of applying science knowledge in their community. With such goals in mind, this study examines the learning opportunities available to students and their application of science learning toward improving community health, with the goal of developing a model for applied science.

1.4 Research Design

This study used a complementary qualitative methods approach to explore the role of place-based science education in fostering student-driven community health interventions. To do this, I worked with community leaders, teachers, and students to develop and study an education program with the goal of improving knowledge of health and sanitation in a Kenyan village. While students selected the health topics and problems they hoped to address through participating in the club, the topics were taught with a focus on providing opportunities for students to learn the practices of science and health applications of these practices. Students learned chemistry, physics, environmental science, and engineering to help them address the health problems they had identified in their community. Surveys, student artifacts, ethnographic field notes, and interview data from six months of field research were used to examine the following questions:

1. In what ways were learning opportunities planned for using science and engineering practices to improve community health?
    a. In what ways were opportunities for learning science and engineering practices and improving community health planned?
    b. In what ways were community and place leveraged to plan learning opportunities?
    c. What student interests were leveraged to plan learning opportunities?
2. In what ways did students apply science and engineering practices and knowledge learned from the health club in their school, homes, and community?
    a. What science and engineering practices and knowledge relating to hand-washing, disease-prevention, first aid, balanced diet, and water management did students report applying?
    b. In what ways did the students initiate behavior changes themselves or within their community through applying these practices?
3. What factors seemed to influence whether students applied or intended to apply what they learned in the health club?
    a. What internal (student-oriented) factors seemed to influence students' applied learning?
    b. What external (environmental, political, financial) factors seemed to influence students' applied learning?
    c. What relational factors between the target group (health club students) and the community seemed to influence students' applied learning?

d. What science education (health club) factors seemed to influence students' applied learning?
e. What cultural factors and bridging strategies seemed to influence students' applied learning?

Following the introduction, this paper will provide an overview of relevant literature in Chapter 2 relating to constructivism, place-based science education, health intervention models, and science and health education in Sub-Saharan Africa. Chapter 3 then describes the methods of the study including the approach taken, context, participants, researcher, relevant prior studies, data collection, and data analysis. Next, the findings are organized in Chapters 4, 5, and 6 by addressing each of the research questions listed above in each of the three chapters. Finally, a discussion of the implications, limitations, and future directions of the research are included in Chapter 7.

Chapter 2: Literature Review

This literature review provides a theoretical and conceptual background for the study based on foundational literature and recent arguments in the field of education related to sociocultural aspects of science learning. Section 2.1 of this review provides an overview of the conceptual framework and theory guiding this study. Section 2.2 of this review describes the constructivist framework, foundational perspectives on the nature of learning as socially and culturally constructed from social and cultural interactions and the lens of prior experiences. Section 2.3 of this literature review examines the constructivist perspectives in practice and introduces recent discussions in science education literature on the role of place in learning science. Section 2.4 looks at another application of such debates in the context of community health education. Lastly, since a study focused on connections between science education and place requires an understanding of the specific place and educational concerns where this study takes place, Section 2.5 explores these concepts in the context of Sub-Saharan Africa.

2.1 Conceptual Framework

This study is framed by sociocultural constructivist perspectives, which suggest that learners construct knowledge from social interactions and prior experiences. Within this conceptual framework, learners use science and engineering practices to move within and between different social activities, contexts, and cultures. In this sense, students cross borders between their local place and scientific social communities through sociocultural interactions and science and engineering practices as will be discussed further in Sections 2.2 and 2.3 below. It is important to note that from this perspective, both the students' local place/community and the scientific community include equally valuable scientific practices and knowledge even though students may perceive them as separate worlds. Traditional school science (typically grounded in more western science practices) may make differences between a student's place and science more pronounced, while science education that connects to community and place may help link the worlds for students (See sections 2.4 and 2.5).

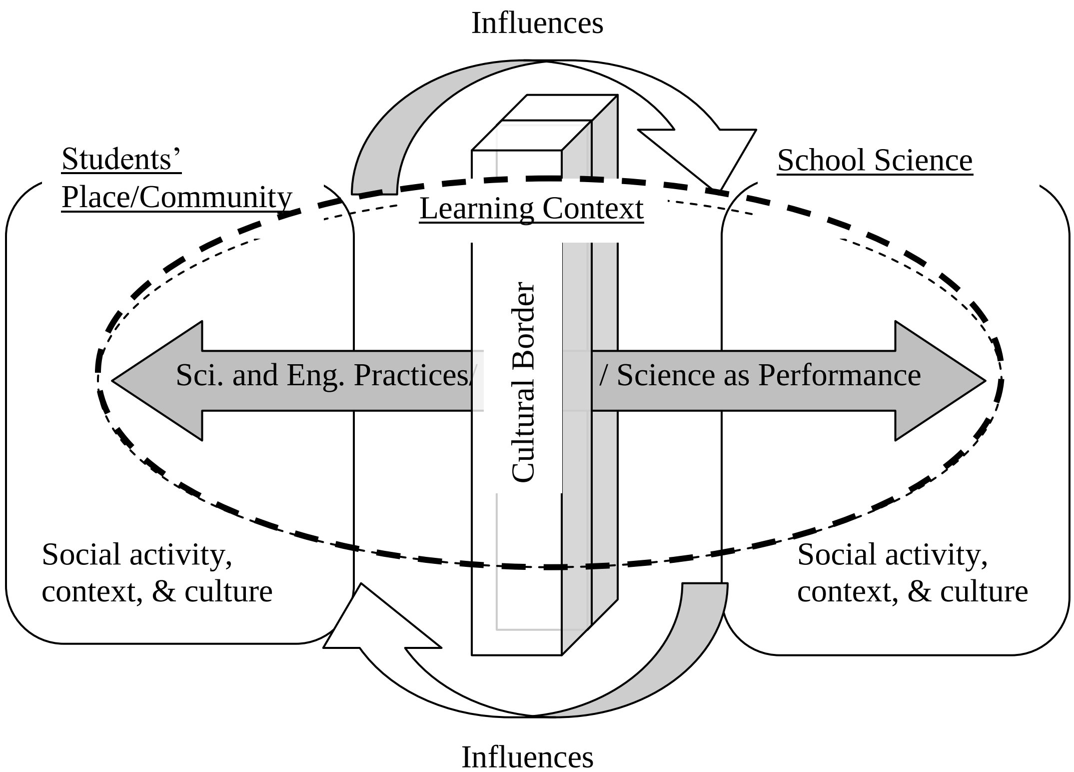


Figure 3. Conceptual framework integrating sociocultural constructivist theories of learning and of learning science, border-crossing, place-based science education, and science and engineering practices.

The conceptual framework in Figure 3 connects multiple theories of actual and ideal learning into a learning context for the health club in this study. The two disconnected worlds of students' place and school science (Cooper, 2011) are shown in the rectangles on either side of the figure. These worlds each consist of their own social activities, contexts, and cultures (Fosnot, 2005; Vygotsky, trans. 1986) and participants in those worlds learn specific ways of thinking, knowing, and doing (Lave, 1991; Lim & Calabrese Barton, 2006). While these worlds are often divided by vast cultural borders (Jegede & Aikenhead, 1999), they have the potential to influence each other. Students' place can influence their school science learning (Brandt & Carlone, 2012), and students' school science learning can influence their place (Chinn, 2007). These influences can be facilitated by students' learning environment or cultural brokers to be positive influences on the community and student learning. These influences have the potential to become two-directional when they are grounded in performance, or science and engineering practices (Le Grange, 2007). Based on these theories, the learning context of this study (shown in the transparent grey striped oval) provides specific opportunities for students to practice science and engineering, while the data analysis explores the influences that occur outside of this learning context. Specifically, this study examines the ways in which students apply their learning toward improving health in their community. The theories that inform this framework are discussed in further detail in Sections 2.1, 2.2, 2.3, and 2.4 that follow.

2.2 Learning as Constructed

Through a theoretical lens of social constructivism, learners are culturally situated and experience unique perceptions and conceptions about their interactions with the environment and with others. Constructivism developed in response to existing behaviorist paradigms where individuals were thought to learn a predetermined sequence of knowledge in response to external stimuli (Fosnot, 1996). Foundational work toward developing a working theory of constructivism stemmed from the work of several cognitive psychologists including Vygotsky, Montessori, the later work of Piaget, Bruner, Davidov, Leont'ev, Galperin, Luria, Gardner, Goodman, von Glasersfeld, Bauersfeld, and others (Fosnot, 1996; Cobb, 1996). Social constructivist theories of learning have significant implications for how learning is understood, how educators develop experiences for students to help them learn, and how learning is researched.

In contrast with the prevalent theories of learning and psychology of his time, Vygotsky, in Thought and Language (trans. 1986), emphasized that individual learning is strongly situated in the social activity, context, language, and culture in which it occurs. Even at a young age, children internalize social interactions which then guide their own actions and decisions. In Vygotsky's social constructivism, learners construct meaning from social interactions they participate in and observe over time (Fosnot, 2005). As learners interact, the synthesis between the learner and who or what they interact which results in new understanding. Over time, the field of cognitive psychology has developed to support a constructivist theory of learning (Cobb, 1996; Ford & Forman, 2006). As Fosnot (2005) explained, "The 'mind' is a result of the human construction of coherence, of explanation within communities of discourse as problems are posed and solved" (Fosnot, 2005, p.1). As a theory of learning, constructivism helps teachers plan and prepare opportunities for students to construct knowledge though constructivism itself is not a theory of instruction.

Social constructivism, which stems from a cognitive psychology paradigm, and constructivism that stems from a science education paradigm are different theories that can in fact be complementary (Bächtold, 2013). Constructivism from a science education perspective posits that not only is learning constructed from social interactions, but that individual learners construct knowledge through the lens of prior experience and common sense (Driver et al., 1994; Julyan & Duckworth, 1996). In this sense, learners build knowledge from their prior informal science ideas and everyday experiences. Knowledge construction then occurs when the learner interacts with physical experiences and/or conventional science concepts and models that have developed socially into accepted scientific practice over time (Driver et al., 1994). The synthesis between prior knowledge and new experience or social norms results in conceptual change and the construction of new knowledge.

John Dewey (1974) recognized the need for students in classrooms to learn practices similar to those of experts in a given area. As students position themselves in social systems, the discourse and ways of thinking, knowing, and practicing science act as resources and connect students with a scientific community (Lave, 1991). DeBoer's exploration of science literacy goals for education suggests that the main purposes of teaching science are to prepare students to (1) understand the cultural force of science in the modern world, (2) prepare for the world of work, (3) apply science to everyday living, (4) become informed citizens, and (5) develop a particular way of examining the natural world, among others (DeBoer, 2000). From these goals, it is apparent that science is largely connected to society and culture both globally and in students' everyday lives. Expert scientists socially construct meanings and norms about the subject in their everyday practices (Latour & Woolgar, 1986). If we want students to learn authentic scientific practices, Brandt and Carlone (2012) suggested that we must bring some of the social practices from the expert scientists into the classroom. They proposed that a cultural perspective of science education is critical for identifying and altering inequalities in science education and in addressing concerns of sustainability, health, and social justice among others.

Perceiving learning as the result of social interactions or interactions between prior concepts and new evidence means that individual learning occurs in a social and cultural context. Therefore, learning cannot simply be measured as a transfer of knowledge to the brain or as simply an internalization of external experiences. Rogoff (1994) explained the need for an emphasis on communities of learners, students' learning as they engage in social activity and share what they learn with others. Research can take into account the social aspects of learning as well as involve interactions between the learner and researcher to discover how students communicate their experiences. Understanding learning as sociocultural and as built from learners' prior ideas provides a working perspective for researching students' learning as they interact with each other and share their learning among different communities of practice.

2.3 Science Education that Connects to Place

Since constructivism suggests that learning is both constructed socially and occurs through the lens of prior experience, it is important to recognize the role of students' own sense of place and community as valuable resources and how science education can be relevant to place and community. In this paper, *place* refers to a students' sense of place (how they perceive their culture and local environment), indigenous practices that occur in a student's local environment, and to their local environment itself. The term *place* is typically used in the science education field and will be discussed further in this section. The term *community* here refers to students' social group and the people living in their local environment on multiple scales. For example, a student's school has its own community that is within the larger community of their neighborhood. In this paper, the word *community* on its own will refer to the people living in the village where the study takes place and will include classifying terms like *school community* if referring to a smaller group of people within their village. The term *community* is similar to place, though more commonly used in the fields of health education and public health to expand notions of health from the individual to group scales and to discuss the role of the community in research and practice toward improving health behaviors. Such literature will be discussed further in Section 2.4. When used together in this paper, place and community are similar in that students are part of their place and community and that both place and community are integrated into their science learning experiences for the purpose of enriching students' learning, community behavior, and the environment. Yet, these terms differ slightly in that *place* describes the students' surrounding culture, environment, and individual sense of their culture including values, expectations, and norms, while *community* describes the people who are part of that culture and environment, and whose behaviors reflect and create specific cultural values, expectations, and norms.

Integrating students' place into the classroom can impact how they value and connect to their learning. Davis and Harré (1990) illustrated how students position their learning from their sense of place when they described positioning as both the way people identify themselves in discourse and as a resource they bring to the interaction to negotiate new positions. Often, students' school, family, peer, and community cultures do not match or compete with each other and there exist both challenges and resources across these many worlds (Cooper, Chavira, & Mena, 2011). When science education is positioned within the community and place that students live in, and their education is considered place-based, curriculum involves the larger contexts and cultures represented by the classroom and benefits those students. In this sense, the curriculum acts as a resource between seemingly different worlds (Aikenhead, 2006; Venville, Sheffield, Rennie, & Wallace, 2008). Some researchers (Aikenhead, Calabrese-Barton, & Chinn, 2006; Gruenewald, 2003; Lim & Calabrese-Barton, 2006) also suggest that place-based learning must include children's *own* sense of place and community, that is their physical, biological, social, political, historical, and psychological state of being that informs their learning and their connection to classroom experience.

Aikenhead (1999) suggested that it is important to consider the science practices and concepts unique to students' communities as these are often divided from classroom science by wide fortified borders. Border-crossing, or moving between a student's home and classroom science culture, is then necessary for students to make sense of the science curriculum and make science accessible to all students, especially those of non-western, indigenous, and minority cultural backgrounds (Jegede & Aikenhead, 1999). In a published forum in which Aikenhead, Calabrese-Barton, and Chinn (2006) presented their viewpoints on place-based science education, Aikenhead argued that "learning science as culture acquisition affords an intuitive, holistic, and rich appreciation of students' experiences in a science classroom" (p. 4). In this sense, cultural brokers are necessary as resources to cross borders between competing worlds (Cooper, Chavira, & Mena, 2011). The teacher, by acting as a cultural broker, has the potential to help their students negotiate border crossings and succeed in science (Jegede & Aikenhead, 1999). It is thus the teacher who can guide students between their own community and place toward science and the culture of science itself.

In addition to crossing-boarders between home and school worlds, students learning science have unique cultural and social capital to bring to their learning. Bourdieu (1986) explained cultural and social capital as the knowledge students obtain from certain experiences or interactions and is subsequently "owned" by the students. Students can have individual or collective capital that becomes useful in classroom learning. In science education, if a student has home knowledge, or capital, of doing science that adds value to the science learned in school, that student's capital is likely to have value in the classroom science culture. If, on the other hand, the student has home knowledge of doing science that conflicts with the science learned in school, this capital is perceived to be of little value in the classroom culture. Lim and Calabrese-Barton (2006) use the term lifeworld to describe the situated nature of a student's experience, the shared linguistic and cultural resources they bring to the classroom. These lifeworlds are similar to Bourdieu's cultural and social capital (Bourdieu, 1986), but with the added notion of including multiple experiences, relationships, and histories that shape a student's sense of place. In this sense, a student's lifeworld can be a resource for students in their learning if and only if that capital is valued in their learning community. In their research on science learning in an urban middle school, Lim and Calabrese-Barton (2006) found that a student's sense of place comes from diverse sources and multiple dimensions from their lifeworlds, combines cognition (what they know) and affect (what they want to know), and is highly contextual. Taking students' sense of place into account in the classroom serves to connect students to the science they are learning and with the science community.

While some researchers (e.g., Aikenhead, 1999; Lim & Calabrese-Barton, 2006) illustrate the need for activating students' sense of place in the classroom, others expand on that need arguing that indigenous students' place should be integrated into the broader curriculum and scientific knowledge for all students. Barnhardt (2007) described how native people in Alaska have integrated their knowledge systems and sense of place on a systematic scale, into the school curriculum for all Alaskan students during a ten-year educational restoration effort. One of the initiatives included in the curriculum restoration created the Alaska Native Knowledge Network, a curriculum database, website, listserv, and publication distribution to connect indigenous knowledge to schools. Barnhardt argued that integrating indigenous knowledge and practices into the statewide curriculum will help students connect what they learn in and outside of school, no matter what their background, so that students are not living in two entirely separate worlds. Chinn (2007) also attested to this need in her findings from a 10-day professional meeting on mathematics and science education where she presented a model for integrating Hawaiian indigenous science practices. Chinn argued that science education should focus more on real-world issues from students' own lives and communities and sought to illustrate this to other teachers and professionals at the workshop. Whether directed toward specific students or added to the larger curriculum, when science education is community or place-positioned it fosters interactions and connections between students' own sense of community or place in the context of the classroom.

In addition to bringing students' community and place into the science classroom, it can be additionally beneficial to move classroom science learning beyond the classroom and into the community (Butin, 2003). Supporting students in moving science education from classroom to community can help shape the community and address local needs (Aikenhead et al., 2006; Bouillion & Gomez, 2001; Panter-Brick et al., 2005). By doing so, it is intended to inform the scientific knowledge of the community rather than just school-aged children and students in classrooms can direct their research and learning to address the goals and actual problems of the community. In a case study of a team of 5th grade teachers from a

Chicago elementary school, Bouillion and Gomez (2001) researched the outcomes of a curriculum designed to connect students' school and home community by having the students develop their own projects and work with community partners to solve real-world problems. Bouillion and Gomez found that when students participated in projects that mutually benefitted their own learning and their communities, they demonstrated an increased interest and sense of self-efficacy toward science. Moreover, as a part of their experiences, students presented their science research on concepts such as water quality, erosion, and water conservation at community meetings that influenced policy decisions about the Chicago River. By connecting the classroom with the community to solve mutually-beneficial real-world problems, the students learned science and actively shaped their community and place. In this sense, science education can be directed toward student's own place, to improve where they live and their community (Aikenhead & Calabrese-Barton, 2006; Bouillion and Gomez, 2001; Chinn, 2011). In addition, community-directed science education has been shown to prepare students to become responsible and scientifically informed leaders within their community (Butin, 2003; Ramsey, 1989; Zahur, Barton, & Upadhyay, 2010).

2.4 Health Education that Connects to Community

Like researchers and practitioners in the science education community, those in the fields of health policy, health education, and community development have developed several models for improving health that integrate community and place. One of the predominant early health models, the Biopsychosocial Model, suggests that diseases are caused by interconnected factors relating to the individual, biology, psychological processes, and external relationships. Like Piaget's early work on the social development of individuals

(Piaget, 1959), this model begins to show how an individual's health practice is influenced by social interactions. The Biopsychosocial Model is commonly used in medical practice, but does not fully account for social and environmental factors and others beyond the individual (Fielding, Teutsch, & Breslow, 2010). A more interaction-based model that considers both interrelated health determinants and community outcomes is the Multiple Determinants Model developed first as a field model by Evans-Stoddart and used to understand population health (Kindig & Stoddart, 2003). This model suggests that an individual's interactions with and the interrelations between their social, cultural, physical, and genetic environments influence the health of groups of people. The shift toward this ecological or population health model has changed the focus of health interventions from relying heavily on experts to focusing more on public engagement (Fielding, Teutsch, & Breslow, 2010). The Action Model to Achieve Healthy Campus 2020 Overarching Goals developed by Grizzell (2009) is an example of this shift toward public engagement. The Action Model, shown in Figure 4, operates on multiple scales to consider individual behavior in context as well as social, family levels and broad social cultural levels of health determinants

In addition to a focus on multiple intersecting health determinants, many recent community health models also have roots from Fishbein's Theory of Reasoned Action (TRA) and the Theory of Planned Behavior (Fishbein, 2000; Montano & Kasprzyle, 2008). Both of these foundational theories have a strong focus on self-efficacy and assume that the best predictor of a behavior is behavioral intention which is influenced by individual attitude and.

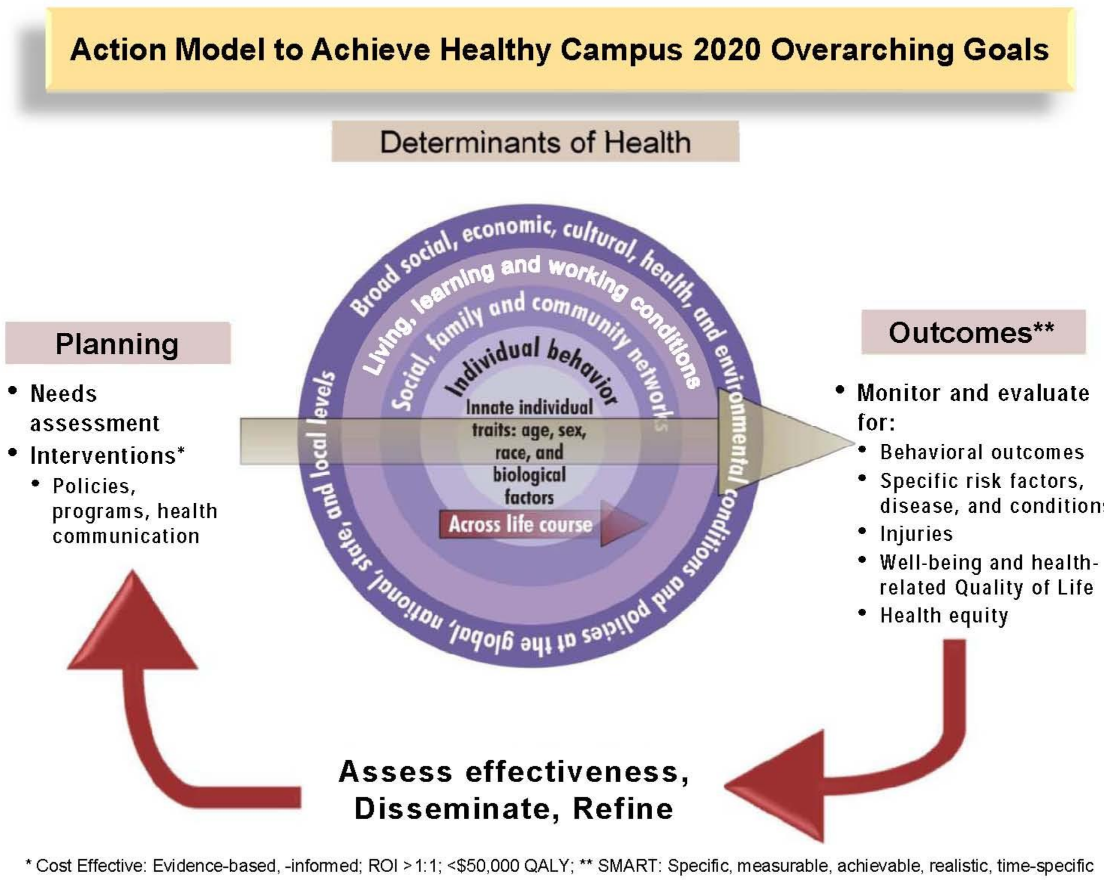


Figure 4. Recommended Action Model as Planning Model with Action Steps Reproduced with permissions from Grizzell (2009). This model is discussed in his "Recommendations to Enhance Action Model for Achieving Healthy People 2020 Overarching Goals and Adapting to an Action Model for Healthy Campus 2020."

social norms. These theories have functioned to predict and explain health behaviors and intentions related to smoking, breastfeeding, HIV/STD-prevention, and the use of seatbelts among others (Montano & Kasprzyle, 2008). With the goal of incorporating other theories with TRA, these theories developed into an integrated model focused on the determinants of behavioral intention (Montano & Kasprzyle, 2008). Figure 5 shows the integrated model where multiple determinants influence an individual's self-efficacy and intentions to perform a behavior, including the behaviors and expectations of others.

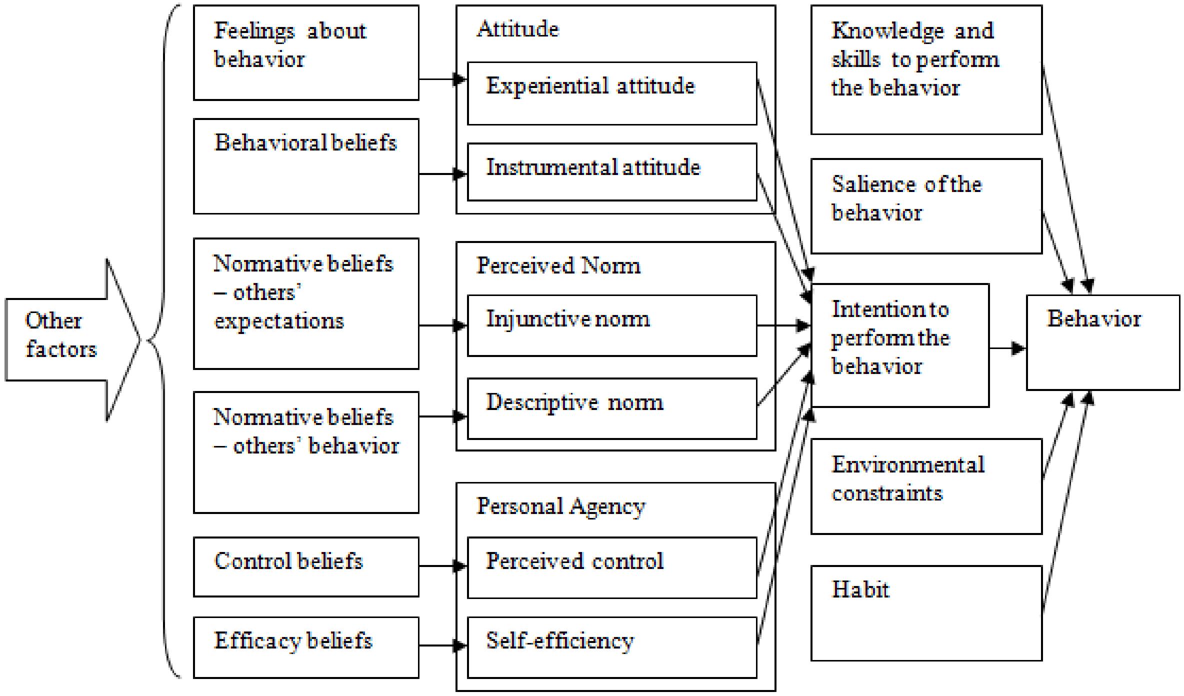


Figure 5. Integrated Behavior Model developed using adaptations of Fishbein's integrated Theory of Reasoned Action (TRA), the Theory of Planned Behavior (TPB), and other influential theories (From Montano & Kasprzyle, 2008).

These behavior models based on social factors on multiple levels (Figure 4) and social influences on individual intentions (Figure 5), also influenced other theories that took into account the sociocultural aspects of behavior change and intention. Panter-Brick and colleagues (2006) developed the Social Ecology Model of Behavior Change with the goal of designing more culturally appropriate, culturally compelling and effective health interventions. Their model, shown in Figure 6 is grounded in a socio-cultural perspective and describes community health practices (Panter-Brick et. al, 2006). Fishbein's multiple social factors that influence an individual's intention to change are considered in a social ecology context where behavior change, including intervention strategies toward such change, is considered on a community scale. In addition, Panter-Brick and colleagues (2006) considered the culturally-compelling enabling factors and limiting factors on community behavior change. As Panter-Brick and colleagues explained, "This [social-ecology model] helps to identify salient determinants of behavior and practical strategies for behavior change in pursuit of cultural effectiveness and public health impact” (Panter-Brick et al., 2006, p. 2824).

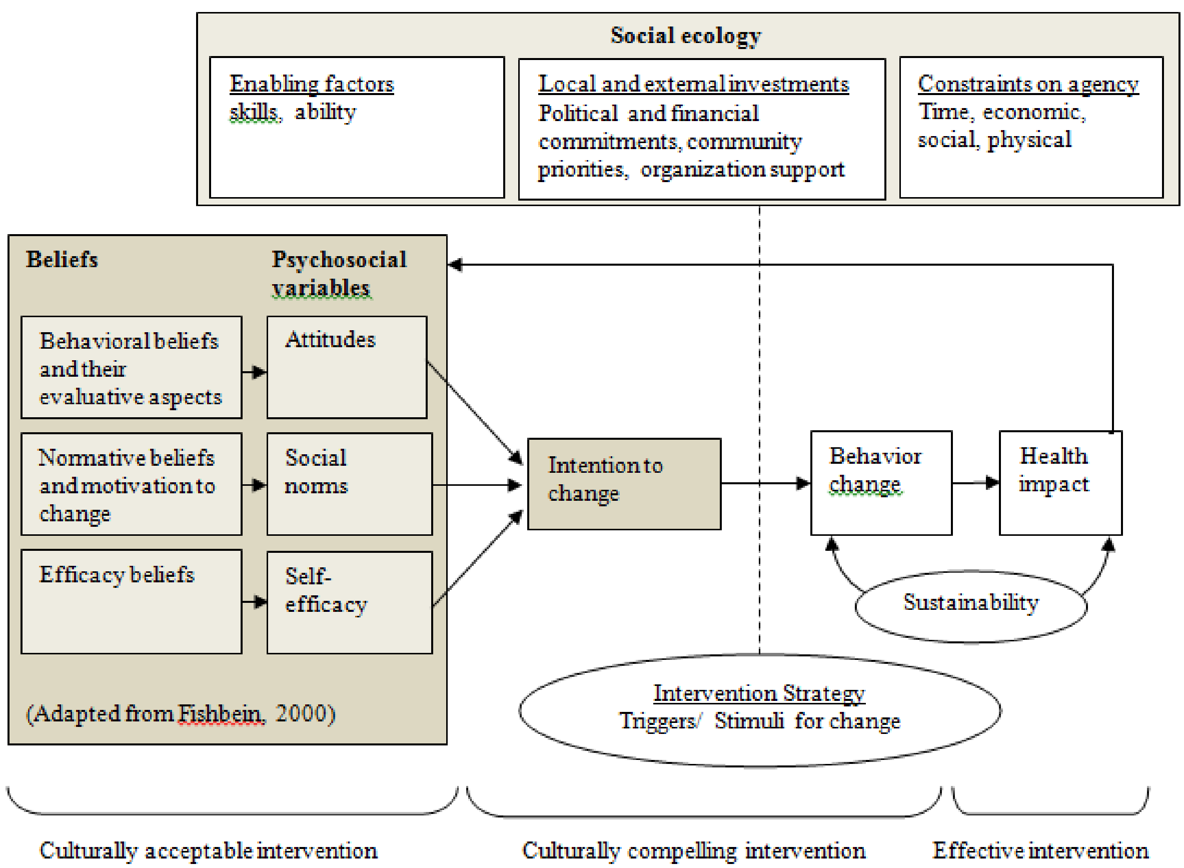


Figure 6. Adapted from the social ecology model of behavior change, for a culturally appropriate, culturally compelling and effective health intervention. The dashed lines, linking social ecology context with strategy for behavior change, are applicable at multiple points (from Panter-Brick et al., 2006).

Models that explain community health behavior change, like that of Panter-Brick and colleagues,’ do more than explain health behavior change; rather, they can be used to support interventions to improve health at the community level. For example, Minkler, Wallerstein, and Wilson’s (2008) Intervention Model focused on school-community action used sociocultural interaction perspectives not just to explain health, but was also used to guide health promotion and risk reduction strategies (Minkler, Wallerstein, & Wilson, 2008). Their model moves beyond using interactive and sociocultural perspectives in models describing community health toward perceiving interactions with the community as *critical* in improving community health. Like Fielding, Teutsch, and Breslow (2010) suggested, these models promote addressing the multiple sociocultural and environmental determinants of health through interventions that integrate public awareness and engagement.

The conceptual framework for this study includes considerations from health models including identifying multiple factors, intervention strategies, and intentions to improve health at a community level. In addition, methods for this study will include both design-based use of such models and the creation of models from evidence. In this way, this study can inform new adaptations of existing models to broaden the potential application of the study's findings.

2.5 Science and Health Education in Sub-Saharan Africa

The disparity between local (indigenous) science knowledge and global (often Western-centric) science knowledge is well-documented, and the difference is especially pronounced in rural Sub-Saharan Africa (Chinn, 2011; Jegede & Aikenhead, 1999; Ogunniyi, 1988). Yet, debates about the positioning of Western scientific knowledge as globally accepted and worthy of engagement, while illustrating the prominence of such practices, fails to account for the idea that western knowledge is one type of local knowledge with its own socio-historical context as Asabere-Ameyaw (2012) explained. According to Semali (1999), "indigenous knowledge is about what local people know and do, and what local communities have known and done for generations" (p. 307). Yet according to Asabere-Ameyaw (2012), another important aspect of indigenous science knowledge systems is also an understanding of these successful ways in which indigenous people use their environments to solve everyday problems and challenges. The literature review below strives to move beyond past arguments on the discontent between proponents of either indigenous and western science (Asabere-Ameyaw, Dei, & Raheem, 2012) and serves instead to illustrate their relative positions in a balanced science education that includes both locally-relevant knowledge and preparation for participation in a global science community (Gitari, 2012).

Valuing local scientific knowledge and practices has implications for improving knowledge and methods in international scientific communities as well as for understanding local environments and local needs. Unfortunately, formal (or western) knowledge and scientific literacy, leftover from a colonial past, is taught in African schools while local knowledge is forgotten (Anamuah-Mensah, 2012). Asabere-Ameyaw explained that even when education is at least better-connected to development needs, such education "is not often theorized and/or operationalized in ways that make sense to local conditions and challenges" (Asabere-Ameyaw et al., 2012, p. 1). Even worse, students are often exposed to science in their community that is at odds with what they learn in school, devaluing one or the other system of knowledge for the students. While they may not realize it, students and educators are surrounded by science relating to indigenous practices, relating to practices of farming, fishing, and medicine to name a few, and such practices have the potential to be connected to their education in meaningful ways.

In a reflection on literature and policy related to how indigenous students learn science, Le Grange (2007) offered a conceptualization for viewing and teaching science through understanding science production as performance rather than just as representation. "Science as representation refers to: abstractions such as theories and laws; the idea of a scientific method; descriptions of the world in textbooks; and so on. Science as performance, however, refers to the doing of science, that is, science is a human and social activity that is messy, heterogeneous, and situated" (Le Grange, 2007, p. 587). Understanding and emphasizing knowledge production as performance in the classroom enables the learner to negotiate and travel among communities of practice, or cross cultural borders which is necessary for learning science (Jegede & Aikenhead, 1999, Le Grange, 2007).

Science education in schools is most commonly driven by the goal that students will shape their community or the global science community *upon leaving school*. In this sense, scientific knowledge and learning in the classroom is separate from action, which typically occurs after individual students graduate. Some researchers argue that this separation between knowledge and action should be better connected (e.g., Chinn, 2011; Leung, Yen, & Minkler, 2004). In a study of students in South Africa, Keane (2008) explored local and western aspects of identity and looked for similarities and differences in worldviews, which are critical to community identity and learning science. Keane found that the community had relevant indigenous knowledge on farming, living with nature, and cultural preservation that benefited both the science curriculum and student learning. Integrating such local knowledge into the curriculum affirmed students' identities and allowed students to express their science learning through community-specific activities including stories and dance. Integrating students' sense of place and community-action into curriculum can make science more relevant and foster interest.

Integrating science education with students' local place also has implications for improving that place. One of the main focuses on improving health and quality of life in developing countries is access to potable water. Water is crucial for survival, yet Too-Kong in the Millennium Development Goals Report (2014), estimates that there were 748 million people still relying on unsafe drinking water sources in 2012. Despite recent progress globally on improving access to water, in Sub-Saharan Africa, less than half of the population had access to safe drinking water (Too-Kong, 2014). Development projects, often started by foreign organizations, attempt to improve access to water; yet, these projects are not easily sustainable. Communities lack the leadership, management, training, supplies, and understanding of proper usage to maintain and make the most of their watersheds and systems (Carter, Tyrrel, & Howsam, 2007). Education is a necessary and often overlooked component of these projects.

Further disconnects between knowledge users and knowledge holders include age and gender. Where there *is* education, it is often the male leaders in the community who are knowledge-holders; however, in most rural Kenyan communities, *women and children* fetch the water, do the wash, boil water for cooking, give water to the animals, and draw water for bathing (van Koppen, 2009). Water permeates many health issues including access to water for hygiene to minimize the spread of diseases spread through direct contact and access to potable water to minimize the spread of waterborne illnesses such as amoebic dysentery and cholera.

Sustainable development, especially relating to water, lies at the intersection of science, technology and society and can be supported through education. In their discussion of a new, global and sustainability-focused curriculum for engineering graduate students, Mihelcic, Phillips, and Watkins (2006) showed the need for engineers and others to integrate environmental, societal, and economic issues when solving problems of sustainability. McConville and Mihelcic (2007) explained how the integration of each dimension of the sustainable futures model functions for water projects. They argued that for water projects to be sustainable, they need to include elements of social sustainability including respect and understanding of local traditions and culture, community participation, political cohesion, economic sustainability and sufficient local resources, and environmental sustainability ensuring that resources are not depleted or destroyed for short-term access to water. For these reasons, science education that is relevant to local issues, such as access to clean water gives students the opportunity to help improve their own communities and make such changes more locally-driven and sustainable.

2.6 Science and Engineering Practices

Learning science and engineering practices allows learners to experience science as performance or action taking place over time that they themselves can participate in, rather than merely as a collection of facts. When science is viewed as performance and action, students are likely to move these actions within and between different social activities, contexts, and cultures (Le Grange, 2007). In this sense, students cross borders between their local place and scientific social communities through sociocultural interactions and science and engineering practices that are transferrable across place and science.

Focusing on science and engineering practices in this study allows for students to learn science through investigations (Bybee, 2011). Moreover, these practices represent goals and teaching and learning strategies. Since this study strives to understand the actions students take (specifically how they apply learning toward improving community health), it is important to place an emphasis on instruction that prepares students for science as action. As Michaels, Shouse, & Schweingruber (2008) explained in *Ready, Set, Science*:

> Science as practice involves doing something and learning something in such a way that the doing and the learning cannot really be separated. Thus, “practice”… encompasses several of the different dictionary definitions of the term. It refers to doing something repeatedly in order to become proficient (as in practicing the trumpet). It refers to learning something so thoroughly that it becomes second nature (as in practicing thrift). And it refers to using one’s knowledge to meet an objective (as in practicing law or practicing teaching). (Michaels, Shouse, & Schweingruber 2008, p. 34)

In this case, education that centers on science practices includes opportunities for students to do something and learn something that helps them practice acting as scientists. In the same sense as science, learning engineering practices allows students to experience and make distinctions between two complementary fields with similar practices (Bybee, 2011).

Here, *science and engineering practices* are used to describe students’ learning of science as performance referring to both the Next Generation Science Standards (NGSS Lead States, 2013) and the Kenya Syllabus science skills (Kenya Literature Bureau, 2009). *Community health behaviors* refers to actions and ways of being, knowing, and doing that relate to local health. These themes are integrated into this study that explores connections between science and place in the context of a rural lake-side community in Sub-Saharan Africa. The science and engineering practices as they were used in this study are further explained in Section 4.3.

Chapter 3: Methods

This study explores planned learning opportunities and students' applied knowledge after participating in a health club in a rural village in Kenya. The health club was community-driven, guided by students' interests in improving health, and provided students opportunities to learn science and engineering practices. I used a complementary qualitative approach with data sources that included ethnographic fieldnotes, surveys, interviews, and artifacts from six months of field research. This data was processed and coded to explore the role of place-based science education in fostering student-driven health interventions.

This methods section serves as an account of the origin, planning, data collection and analysis for the study. Table 2 provides an overview of research activities for this study. Section 3.1 introduces the complementary methods approach and theoretical foundation for the integrated methodologies. Section 3.2 then presents an overview of the geographic and sociocultural context in which the study is situated. Section 3.3 describes the participants, introducing the teacher and students who completed both surveys and interviews. In Section 3.4, I describe myself as the researcher and my position in the community. One year before the study, an engineering needs-based assessment trip was conducted to obtain back ground information and evaluate appropriate educational approaches that would complement engineering efforts. The data obtained from this assessment are included in Section 3.5 since it guided the development of the study. Similarly, Section 3.6 provides a summary of a pre-study conducted at a local Kenyan high school since this preliminary research served as groundwork for the curriculum and surveys used in this study. Section 3.7 lays out data collection methods, including examples of surveys and interview protocols. Lastly, Section 3.8 explains the analytic process in this study including coding schemes and examples.

Table 2

Timeline Overview of Research Activities

Months	Location	Research Activities
Oct. 2011-March 2012	CA, US	Finalized research plans, discussed data collection with contacts in Kenya by e-mail, worked with Engineers without Borders and advisor to discuss research plans
April-July 2012	CA, US	Constructed pre-survey and ethnographic data collection instruments and procured water testing kits and procedures
Aug.- Sept. 2012	Namerokamano, Kenya	Established housing in Kenya, visited local contacts, practiced Luo language, met with principals and teachers, conducted preliminary water tests, obtained research permissions from participants
Sept.- Nov. 2012	Namerokamano, Kenya	Conducted pre-study at local high school and designed potential activities to use in health club
Dec. 2012	CA, US	Returned to US, used pre-study findings to adjust further research plans
Jan. 2013	Namerokamano, Kenya	Met with principal and teacher at the local elementary school to plan the health club and obtain feedback on surveys
Feb. 2013	Namerokamano, Kenya	School year started in Kenya. Co-led meetings with health club, collected pre-instruction survey data
Feb.-March 2013	Namerokamano, Kenya	Observed health club meetings, collected observational data and conducted periodic informal interviews
April 2013	Namerokamano, Kenya	Analyzed initial data, continued collecting observational data and conducting periodic interviews, verified emergent trends with teacher
May- June 2012	Namerokamano, Kenya	Collected post-instruction data (surveys and focus-group interviews)
June 2013	CA, US	Returned to US and continued analyzing data
June 2013-May 2015	CA, US	Analyzed data and wrote dissertation, continued collaborations with contacts in Kenya through letters or e-mails

3.1 Complementary Qualitative Methods Approach

Grounded in the theoretical framework described in Chapter 2, this study used complementary qualitative research methods to understand the role of place-based science education in fostering student-driven community health interventions. These methods included elements of ethnography (Anderson-Levitt, 2006; Green, Skukauskaite, & Baker, 2012; Spradley, 1980), design-based approaches (Schoenfeld, 2006), and model-driven interventions (Fielding, Teutsch, & Breslow, 2010; Glanz, Rimer, & Viswanath, 2006). Specific aspects of these methods were integrated to look across multiple forms of data in order to guide exploration of planned classroom activities, students' self-reports of activities, and external factors of influence on such activities from an ethnographic perspective. Guided by these goals, data collection consisted of multiple forms of records including surveys, interviews, video records, ethnographic fieldnotes, and collected artifacts.

Learning to participate in a community and designing programs that connect with local practices and needs, involves understanding that community from an ethnographic perspective. An ethnographic approach allows people to be studied in their everyday context, with a particular focus on culture as people interact and make meaning of their lives (Anderson-Levitt, 2006). As a study of cultural practices, ethnography allows the social construction of such practices to become visible within the situation and conditions in which they take place (Kalainoff, 2013). An ethnographic approach was used in this study to observe participants and iteratively analyze survey, interview, observational fieldnotes, and artifacts as records. Description and interpretation of cultural behavior through writing is critical to ethnography (Wolcott, 1988), so these practices guided my methodological decisions to record thoughts and impressions as fieldnotes as well as iteratively interpret findings through re-description and re-interpretation of data. Ethnography as an epistemology (Agar, 1994) or logic of inquiry (Anderson-Levitt, 2006) allowed me to explore records as a participant observer and use such explorations to further analysis. For example, since the students selected their own interests related to health, these interests in turn guided analysis of future records. Such an iterative and recursive process enables analysis and methods to evolve as the study progresses and in addition provides a way to adapt analytic approaches as insights and findings emerge across the data.

Participant observation is an important aspect of an ethnographic perspective as ethnography highlights the need for researchers to enter a culture and participate in order to understand what goes on within that culture. Spradley (1980) explained the purpose of the researcher as a participant-observer as a way to understand the semantic relationships of people within a culture (Spradley, 1980). People live in specific times and places, have specific ways of communicating and accomplishing goals, and their actions are socially guided (Fosnot, 2005). These actions and interactions across times and events become patterned until expectations develop. Such expectations of patterned action and principles are understood and used by members of the group to guide subsequent actions, participation, and understanding (Spradley, 1980). With this in mind, if a researcher is to understand actions, participation, and understanding within a community, it is crucial that the researcher also be a participant in that community. Anderson-Levitt (2006) explained that as a participant observer, it is important to attain a dual perspective of both insider and outsider. The insider, or emic perspective, allowed me to obtain the participants' point of view to see the logic of their actions while the outsider, or etic perspective, allowed me to articulate culture and make such actions visible (Anderson-Levitt, 2006). To achieve this balance in perspective, I worked with the community for a period of two weeks when I traveled there two years before designing this study. Then, I lived within the community for about five months before planning and implementing learning opportunities. During these months, I attempted to integrate into the community and began to learn about the patterned actions and expectations that guide insiders.

Design-based approaches informed this study by providing ways to integrate research and practice in a natural (messy) classroom setting while allowing for innovation. As Schoenfeld (2006) explained, design-based research includes entwined goals for designing learning environments and developing theories, research accounts for designed learning opportunities in authentic settings, and relies on methods that document processes and their connection with outcomes of interest. In this research, those three tenets of design-based research were met. The teacher, researcher, and students co-constructed learning opportunities in their school and community with the goal of both improving learning and developing theories. Methods included ways to document both the design aspects, activities and learning in the classroom, and outcomes for how students applied learning. Though this research was largely informed by design methodology, it was not fully a design-based research project. A pre-study allowed for a prior iteration of the design for this research, but this research in and of itself was merely one iteration in what Schoenfeld (2006) suggested is necessary - a continuous cycle of design, enactment, analysis, and redesign. This fourth tenet is a critical aspect of design-based research which, while not directly included in this study, should inform future research and iterations of this study. Key outcomes of design-based research as described by Cobb et al. and explained by Schoenfeld (2006), however, are central to this study. Those outcomes are: “to develop a class of theories about both the process of learning and the means that are designed to support that learning" and that "create the conditions for developing theories yet must place those theories in harm's way" (Schoenfeld, 2006, p. 200). In a sense, this research, like the design-based research proposed by Cobb et al., has a pragmatic foundation. In this case, this foundation comes from the need to (1) better connect science education with place, (2) improve access to science and local health behaviors, and (3) to develop theories grounded in both authentic settings and the activity of design itself.

Models are used by health education researchers to understand a problem or process. As Glanz, Rimer, and Viswanath (2008) explained, models are often guided by multiple theories and empirical findings. In this way, models serve to "explain behavior and suggest ways to achieve behavior change" (Glanz, Rimer, & Viswanath, 2008, p.27). These models can help explain theories of action that guide the design of behavior interventions, evaluate change from interventions, or link theory to practice. In this study, a few commonly used models of health behavior change were used to guide the study design and analysis. In turn, findings are organized in such a way that theories are brought together with empirical evidence to suggest modifications to existing models for use with specific contexts and purposes.

3.2 Context

This study was conducted in Namerokamano (pseudonym), a community on the banks of Lake Victoria in Nyanza, Kenya, in 2013. Lake Victoria is bordered by Kenya, Tanzania, and Uganda (see Figure 7). Lake Victoria is the source of the Nile River, with 11 nations sharing its basin and relying on its water. In this region, life depends on Lake

Victoria for fishing, drinking, washing, and cooking; yet, its water is highly contaminated, as indicated by exorbitant amounts of *E. coli* and total fecal coliform which will be discussed later. The community health clinic in Namerokamano regularly treats water borne illnesses such as dysentery, typhoid fever, and cholera. While treating these illnesses is adequate for improving health in the community, subsequent measures to prevent the bacteria from spreading would further this effort (Engineers without Borders UC Santa Barbara Chapter, 2010).

Solutions for improving access to clean water in Namerokamano have been implemented by the community in conjunction with the University of California - Santa Barbara (UCSB) chapter of Engineers without Borders. These projects include a rainwater catchment system at the health clinic and a well. Also, another groundwater system is currently being constructed to reach a greater portion of the community. While these systems provide clean water sources for the community, initial water tests (see Section 3.5 on needs-based assessment) indicate that contaminants enter the water after it leaves the tap (Wright, Gundry, & Conroy, 2004). To ensure that the water stays clean, the community requires more than engineering. People who use the water need to change their practices for collecting and storing water. In addition, they need the skills to properly maintain, finance, and repair the systems. For example, the well includes a fluoride filter since local groundwater has a high concentration of fluoride. This adds an additional element of complexity to the system and most importantly, a need for understanding that filtered and unfiltered water should be used differently (Braune & Xu, 2009). Each water system requires specific skills in management, maintenance, and use. While there is a water committee for each system comprised mainly of men, the women and children in the community who collect, store, and use the majority of the water need to be educated to improve their practices with these systems.

Figure 7. Map of Kenya showing Lake Victoria and the countries along its Eastern banks. The circle highlights the lake shore region in the Nyanza province where this study takes place.

3.3 Participants

Participants were all members of a Health Club that consisted of approximately 25 students, one teacher, and me. The club met two times per week at the local public primary school, the equivalent of US pre-school to grade eight. All school instruction was conducted in English or Kiswahili though students speak a language called Kijaluo (also called Luo or Doluo) at home. In school, students took classes in English and Kiswahili, mathematics, religion, social studies, and science. In science, the students had been planting trees around their school for at least three generations. These students had substantial knowledge about planting and animals since there were many farms.

Twenty-five students were selected by the participating teacher, Madame Atieno (pseudonym), to join the health club based on an interest in science or health, sufficient communication skills in English, and enrollment in grades five through eight (ages 10-14). Mme. Atieno taught Kiswahili, math, and science to students in grades 1-5 and was responsible for improving school health. At the time of this study, she was also enrolled in special education classes to earn certification as a special education teacher. The health club members are shown in Figure 8 below in front of their school and in Figure 9 in the classroom where the club met.

The health club participants were very interested in personal health, sanitation and in improving their school community. In the US, when students get a cold or flu, it is not usually much more than an inconvenience; they may miss a few days of school, but the majority survive without long-term consequences. In Namerokamano because of issues like malnutrition, HIV/AIDS (which about 25% of the community has as reported by the local clinic), and poor sanitation, such illnesses or injuries can be fatal. During the school year

Figure 8. Health club members, Mme. Atieno (far right), and me in front of the rainwater system the health club designed.

Figure 9. Mme. Atieno and a group of students making a health book.

when this study was started, three students at the school passed away due to illnesses that would not likely have serious effects in more developed areas. The students in the health club were motivated to make changes and prevent this from happening in the future. Table 3 introduces the students in this study, their gender, age, grade, favorite subject, and proposed career. Their favorite subject and proposed career are included to show that most of the health club members were selected because of an interest in learning about or pursuing careers in science.

3.4 Researcher

I was born and raised in Southern California where I became accustomed to two seasons, warm and hot. In Kenya, the seasons are rainy and dry and the weather is similar. In some sense, that is where my emic perspective ends though I find that humans in general share more commonalities around the world than we often realize. That said, it should be noted that I am a female American of European descent and I do stand out in rural Kenya. In fact, coming from an urban area and entering a rural community seemed the most substantial difference between my perspective and the community of Namerokamano, more so than ethnic or racial background. Being a female came second in my identity to being American. A good example of this was when I was honored at the Engineers without Borders going away party. One of the village elders said that my parents, who were unlucky in only having one child, were blessed by God in having a girl with a boy’s skills (I believe he was specifically referring to my impromptu masonry work). That said, I was able to communicate reasonably well with both male and female community members. I also studied the local language by listening and talking to children beginning on my first trip to Namerokamano in

Table 3

Health Club Participants (N=20) Who Regularly Attended Classes, Completed both Pre and Post-Surveys, and Attended a Focus Group Interview Session. Data were Collected on the Pre Survey

Student (pseudonym)	Gender	Age	Grade	Favorite Subject	Proposed Career
Anna	F	11	6	English	Teacher
Apiyo	F	14	8	English	Surgeon
Beth	F	13	7	Mathematics	Lawyer
Brenda	F	13	6	Science	Doctor
Oroko	M	13	7	Mathematics	Engineer
Danny	M	14	8	Science	Engineer
David	M	11	5	Mathematics	Lawyer
Jacob	M	10	5	English	Teacher
Jeff	M	14	7	Christian Religion (CRE)	Lawyer
Jenna	F	12	7	Mathematics	Nurse
Katherine	F	13	7	Mathematics	Doctor
Matthew	M	12	5	Science	Doctor
Nasir	M	14	7	Mathematics	Teacher
Noah	M	12	6	Science	Meteorologist
Owino	M	12	6	Science	Astronomer
Paul	M	14	8	Kiswahili	Doctor
Samuel	M	11	7	Mathematics	Doctor
Teni	F	12	6	Science	Doctor
Victoria	F	11	5	Mathematics	Nurse
Zachary	M	13	7	Mathematics	Surgeon

Note. In addition to the 20 students listed, five additional students participated in the focus group interviews and came to occasional health club meetings, but did not have pre or post-survey data or participate regularly. These students, Faith, Marie, Doreen, Jarrod, and Isiah (pseudonyms), are not included in coding and analysis, but some of their interview transcripts are used to provide examples and support emergent themes in this dissertation.

2011. Being able to greet elder women and young children in their mother tongue lowered my barrier to entry into the community and helped me develop friendships.

In August 2012, I traveled to Kenya to research potential methods for integrating a community-driven education program with water development engineering projects to achieve sustainability and improve access to potable water in rural areas. In the first month of my trip, I settled into daily life in the community and worked with Engineers without Borders- Santa Barbara to install a groundwater pump. I found myself learning and doing something new every day, from greeting elders of the community in their local language, laying stones for a pump house, and testing water for fluoride levels to leading meetings with water committees. After completing the water project, my research on how to integrate education to support it commenced. I spoke with people at the water site to determine their current understandings of connections between water and health. Many people were afraid to drink the water from the new borehole because it tasted saltier than the lake water and came from under the ground which they believed made it dirty. Others were aware that they should not drink water from the lake, but did not know why. Community members were aware of the waterborne illnesses common in the region and concerned with the health effects of drinking contaminated water.

3.5 Needs-Based Assessment

Prior to collecting data for this study, I traveled with Engineers without Borders to Namerokamano, Kenya for two weeks in 2011 to implement a project and conduct a needs-based assessment in the community. During this trip, my team and I collected water quality data (included in Appendix D) and interviewed women and children at one of the groundwater wells we had worked with the community to develop. In these informal interviews, we asked about water use, time spent collecting water, health issues relating to water, and other health issues they faced. Their responses guided future work with the community and led to discussions with local leaders. In discussions with local leaders, we also discussed community needs, especially those relating to education. The leaders felt that their own students should be better prepared to take an active role in science and engineering done in the community. These discussions led to plans for educational research to learn more about how this can be done. These plans as well as monitoring data from the interviews at the well informed a formal document assessing the engineering and educational needs of Namerokamano.

I returned to Namerokamano a year later to plan this study. During the first six months of that time starting in August 2012, I interviewed and observed the community, learned to fetch water and immerse myself in the culture to better understand where people's ideas and needs came from, and began developing a program for educating the community to help meet these needs.

3.6 Pre-Study

In a study that preceded this one from September to December 2012, I identified factors that led to limitations high school students faced in connecting science to their place and community. These factors were intentionally attended to in this research and were particularly useful as contrasts with factors that supported elementary students in this study in connecting science to their place and community.

In the pre-study, I worked with a teacher at a local high school to design a health club. The teacher and I learned that calling it a health club attracted those students who truly wanted to help their communities. These students demonstrated an interest in learning the connections between health and water. Their teacher and I designed opportunities for them to do authentic science research to determine these connections. For one activity, the students collected water from two different sources at their school: a rainwater tank, and a well.

Though most students expected the rain water to be better for drinking, they discovered that the bacteria colonies found in the rainwater were much higher in number than those found in the ground water. This allowed them to see the difference between the water sources in a new way, share their findings to convince other students to use the groundwater rather than the rainwater for drinking, and brainstorm improvements they could make to the rainwater catchment system to make the water safer for drinking.

This initial study was discontinued when the participating teacher left the school and it was difficult to continue without her support. In addition, the high school students had a rigorous schedule that did not allow substantial time to learn things outside of their regular classes. Most importantly with regards to this research, the initial study was unsuccessful in terms of bridging knowledge from students' classroom to their homes since the high school was a boarding school and students rarely interacted with the surrounding community outside the school grounds; however, the initial study helped formulate my research methodology for this design-based project and became a useful comparison for understanding some of the factors that influence students' abilities to apply science learning toward improving health in their community.

3.7 Data Collection

Data collected for this study included pre and post-surveys, ethnographic observations and fieldnotes, focus group interviews, and artifacts of opportunities for student learning. Surveys were used to obtain demographic information, compare students' perceptions of health issues in their community, and offer written means to understand how students applied their science learning in their community. Focus group interviews were conducted after six months of health club meetings and observations to verify emergent findings and allow students to conversationally discuss their interests in health and ways in which they applied science learning in their community. Artifacts, including lesson plans and student work, were obtained to better understand opportunities for student learning and trace activities over the course of the health club meetings. Additionally videos were taken of most health club meetings, though this data source was only used to verify written records and timelines for planned learning opportunities.

Surveys. Pre surveys were administered to students in January, 2013 and post surveys were administered in June, 2013. The surveys were administered in English, with Mme. Atieno and I there to answer any clarification questions related to the language of the questions. Students had unlimited time to complete the surveys and returned to collect them from Mme. Atieno to continue working on them as needed. Pre and post-surveys were designed with mainly free-response and drawing-type questions or questions formatted similarly to those asked of students on national exams. This formatting was suggested by the teacher so the students would be familiar with the structure and more likely to respond. Questions included those for better understanding students' health behaviors and use of science and engineering practices, understanding of relevant science and health concepts, interests relating to health in the community, and opportunities to evaluate their own opportunities for learning in the health club. Examples of survey questions for different purposes are provided in examples 1 through 6 below. For complete pre and post-surveys, see Appendix A and Appendix B respectively.

Table 4

Description of Data Sources Collected to Address Each Research Question

Research Questions	Data Sources
1. In what ways were learning opportunities planned for using science and engineering practices to improve community health?	Ethnographic observations of health club meetings - recorded through ethnographic fieldnotes and video where appropriate Artifacts of student learning opportunities – lesson plans and student work collected during six months of the health club Pre-surveys – open-ended questions about students' interests relating to health issues in their community
2. In what ways did students apply science and engineering practices and knowledge learned from the health club in their school, homes, and community?	Ethnographic observations of health club meetings and students in the community - recorded through ethnographic fieldnotes and video where appropriate Post-surveys – multiple choice and open-ended questions about students' applications of science and engineering practices and knowledge Focus group interviews – semi-structured group focus group interviews with students six months into their participation in the health club
3. What factors seemed to influence whether students applied or intended to apply what they learned in the health club?	Ethnographic observations of health club meetings and students in the community - recorded through ethnographic fieldnotes and video where appropriate Focus group interviews – semi-structured group focus group interviews with students six months into their participation in the health club

Examples of open-ended, free-response questions to access students' perspectives on health concepts and science and engineering practices:

1. How can people become sick? (draw and explain)
2. What can you do if your younger sister has a fever (a high body temperature)?

Examples of multiple choice selection questions for assessing understanding and home health behaviors:

3. When should you wash your hands?

- ☐ Before I eat
- ☐ After I eat
- ☐ After I use the latrine
- ☐ When I am sick
- ☐ After I shake a sick person's hand
- ☐ Before I cook
- ☐ When I help someone who is hurt
- ☐ Other: ____

4. How does your family treat drinking water?

- ☐ Filtering
- ☐ Boiling
- ☐ Water Guard or Chlorine
- ☐ Other: ____
- ☐ My family does not treat drinking water

Examples of survey questions to understand students' reflections of learning opportunities provided:

5. Describe one of the water research projects you or another student in the health club did. What water was tested? What were the results? How can these results help improve the health and sanitation of your home?
6. If the health club continues next year, how can it be better?

Ethnographic observations and fieldnotes. Time spent with participants as a participant-observer enabled me to better understand their roles, values, lifestyles, and typical behaviors. As a participant-observer during the health club, I co-taught with Mme. Atieno, asked students questions during hands-on activities, and posed my own questions. The health club met approximately 25 times during this study. I attended all, but a couple of the meetings. I often walked around the front of the classroom and led discussions during the first few months of the health club, but after about three months I began to minimize my involvement spending more time listening and taking video from the back left corner of the classroom. After these times as a participant-observer, I recorded observations and experiences as ethnographic fieldnotes. Fieldnotes were jotted down at the end of health club meetings and expanded later that day, but while the memories were still fresh (Emerson, Fretz, & Shaw, 1995). These ethnographic fieldnotes were then later used to apply meaning to the data, set up conceptual categories, and help identify relationships (Mostyn, 1985). Some of the observations included in my fieldnotes, as suggested by Bogden and Biklen (2007), included portraits of the students, reconstruction of dialogue during the teacher's lectures and class discussions, descriptions of the class setting, and depiction of activities.

Focus group interviews. Focus group interviews with three to six students in each of six sessions were also conducted from May 28th to June 11th, 2013 and were video recorded. All 20 participants included in this study participated in one of the six group interview sessions. I initially tried to group students by age and gender to have students of similar age and the same gender together, but scheduling conflicts made this difficult. The questions in the focus group interviews were intended to complement the surveys and to help offer multiple forms of communication between myself and the students. The interviews were semi-structured and students were asked to discuss what they learned across different areas of health, what and how they shared what they learned in their home and school, and questions relating to their attitudes toward sharing what they had learned and the program in general. The interview protocol is included in Appendix C. During interviews, I used some of the key techniques described by Spradley (1979) including stating an explicit purpose, asking for frequent explanations, and using descriptive, structural, and contrastive questions to encourage rich conversation. Four of the six interviews were conducted in the health club classroom by moving two benches together so that students could face each other and me around the benches. Because of limitations in classroom space, two of the interviews were conducted outside under a tree with the similar bench configuration. This provided challenges in hearing students because of younger students playing nearby, birds and other animals making sound, and wind noise that was especially distracting in video recordings.

Artifacts of student learning opportunities. Artifacts were collected to explore the opportunities for learning that students were provided through participating in the health club. These artifacts included lesson plans, student writing, student water data, and a class book project. For example, students conducted water tests for fecal coliform and *E. coli* in their homes to test a predicted difference between water sources and/or treatments. To obtain these results, students used whirl packs for collecting water, 3M Petrifilm *E. coli*/Coliform Count Plates, pipettes and bulb, and a ziplock bag to incubate their count plates at body temperature overnight. Students analyzed their results in class and photograph records were kept for their findings.

3.8 Data Analysis

This study used a complementary qualitative methods approach to explore the role of place-based science education in fostering student-driven community health interventions. This section explains the methods for analyzing the data in this study. First, an overview of the analytic procedure is provided in Figure 10. Then, the coding process for interviews and surveys is described. Examples and a coding scheme are included to clarify specific decisions made regarding the analytic process.

Prior to this study, an engineering and education needs-based assessment was performed as part of Engineers without Borders with the goal of making engineering projects more sustainable and providing relevant outreach in the community. This needs-based assessment led to a pre-study at a secondary school where curriculum and research methods were tested. This pre-study also served as a contrastive analysis to help determine factors that supported and constrained students' application of knowledge in their community. Emergent findings from the pre-study then informed survey designs and the focus of observations in this study. Pre-instructional surveys and early observations were analyzed during data collection to iteratively inform the curriculum and design-based study methods. Resulting artifacts from the health club and additional observations were collected throughout the health club. These data also served to inform focus group interview protocols and post-instructional surveys. Finally, all of the data collected throughout the study were iteratively analyzed from an ethnographic perspective to explore emergent themes and compare these to existing science and health education theories. This analytic process, shown in Figure 10 above, is explained in further detail below.

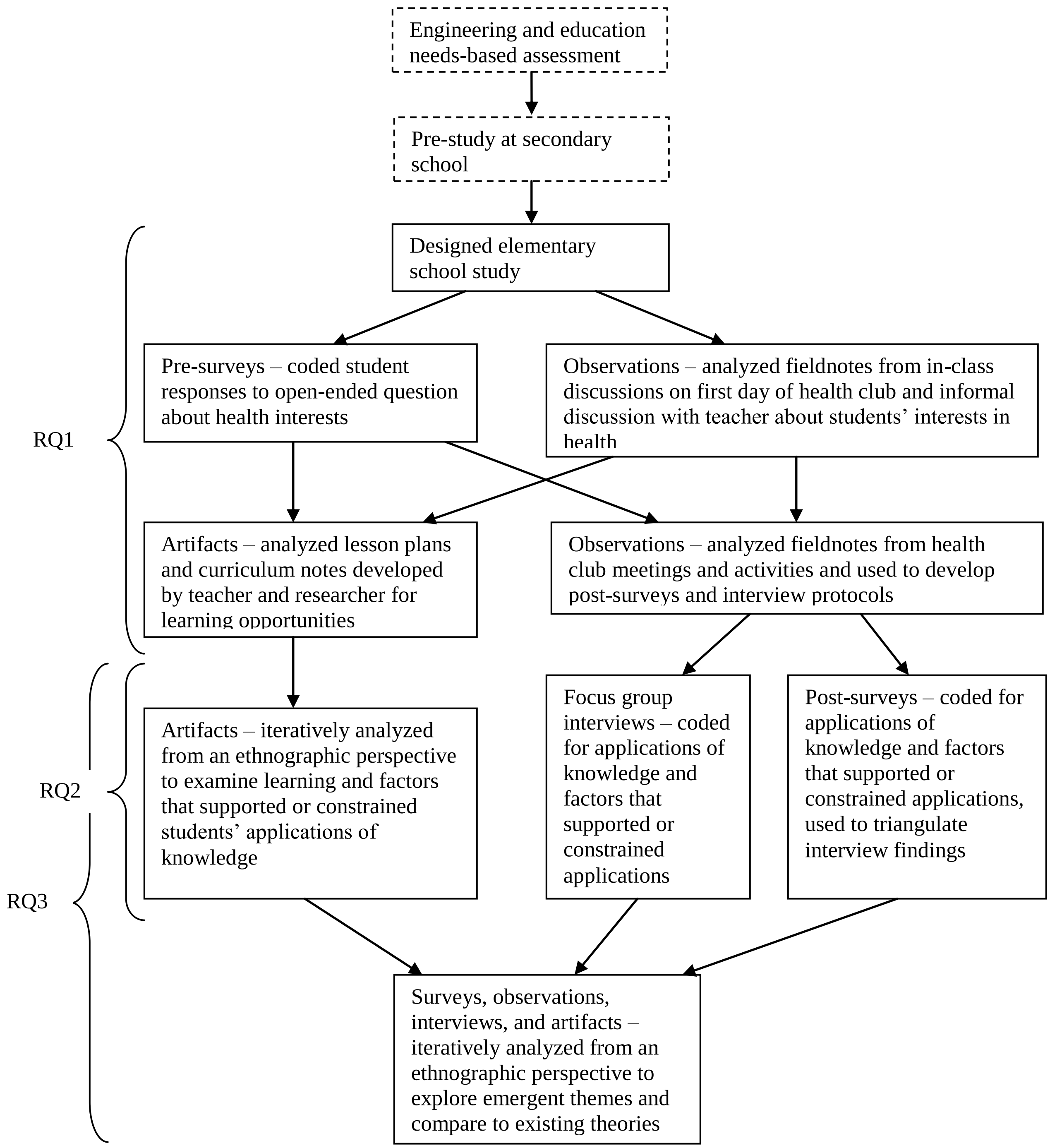


Figure 10. Flowchart of analyses performed across multiple sources of data. Arrows represent where one analysis informed another in an iterative and recursive process. Dashed lines indicate analyses performed prior to this study. The research question (RQ) addressed by each stage of analysis is indicated on the left.

For planning purposes and to address research question 1, surveys were analyzed using process and structural coding techniques for free response questions (Saldaña, 2013). First, pre-surveys were coded to analyze students' interest in health topics and problems they wanted to solve using what they learn about science (see Table 5). The topics were emergent from students' answers to the question, "What do you want to learn most about health?" though they also reflect the curriculum units since those were developed directly from students' interests.

Frequency counts of the number of students who selected any given interest code allowed me to explore differences in student-interest across topics. After emergent coding from this question, students were then given a code for having an interest or no interest expressed for each topic that was used in later comparisons, which helped address research question 2. In addition, pre-surveys were also coded for connections students made between each of these topics and health using three relevant open-ended questions. For example, if a student described washing hands as one way they stayed healthy then they would be given a code for connecting hand-washing to health. If a student did not mention a connection, it does not necessarily mean that the student did not perceive a connection between that topic and health, merely that the student did not mention that topic in open-ended questions regarding general health. For research question 1, fieldnotes and artifacts (including lesson plans and curriculum notes) were also used to examine planned opportunities for learning. These were organized chronologically and later by health topic to connect with students' applied learnings.

Table 5

Coding Scheme for Pre-Survey Open-Ended Question on Students' Interests in Health

Code Word	Description	Example
Hand-washing	Interests relating to how or when to wash hands, why being clean is important, and how to have good hygiene	"Washing our hands… how we can clean our body"
Diseases	Interests relating to understanding causes, symptoms, or cures for specific diseases, how to prevent the spread of diseases, how to reduce diseases in community	"I want to learn about how I can have good health and how I can prevent the diseases which mostly attack us in the society and their control. The diseases are: cholera, diarrhea, typhoid, bilharzia and the STIs which commonly caused by using or sharing"
First-aid	Interests relating to response to help in specific health-related situations including treating someone who is sick or injured	"How to treat a person who has fainted who has a cut …who is stung by a bee."
Water	Interests relating to health concerns with water quantity or quality, water sources, treatment, testing, or storage practices	"What I want to learn most in health is how to prepare safely water to drink and what type of water can we use hard or soft?"

To address research question 2, post-surveys were coded similarly to pre-surveys with the addition of a score for each health topic. Health topics were based on students' interest codes from pre-survey data, including *hand-washing, diseases, first-aid, water,* and one additional code for *balanced-diet* that emerged from observational fieldnotes on students' interests developed during the health club. The scores for each section of the post-survey were determined across multiple questions for each topic to help determine students' general understanding in that area. For example, the balanced diet section included questions in which students described the health benefits from having a balanced diet and another question where they selected multiple options regarding what combinations of local foods represented a balanced diet. Students were scored for these two questions and given a qualitative code based on their responses indicating a low, medium, or high understanding of the topic. Post-surveys were also coded for students' reported applied learning or intentions to apply their learning toward improving community health.

Codes from post-surveys were later used to triangulate interview data. In cases where students described an application in writing on their survey, but not in the focus group interview (e.g., for cases where verbal language was a barrier), an application code was supplemented from the survey to create an inclusive list of all applications described in either writing or verbally.

Interviews were first transcribed and coded by turn of speech to identify students' ideas and applications (the actions or intended actions students took toward improving health in their home, school, and community). When no science/health ideas or applications were discussed, no code was given. Applications were labeled by the language students used to describe them to determine if the application was intended or applied by the student. Additionally, applications were identified by their reach (*home, school, or community*) and by their type (*teaching or action*). For example, if a student said, "I should teach my classmates to wash their hands," the application was labeled as an *intention to apply.* In contrast, if a student said, "I taught my classmates how to wash their hands," the application was labeled as *application*. In both examples above, the students talked about teaching their classmates so the reach in these cases was coded as *school.* Specific information about the application was also coded. In the examples above for instance, an additional code was added for *teaching* as the type of application.

To examine students' applications across all topics, two methods were used. First, each student was grouped into low, medium, and high application groups based on their applications across topics. Students who applied their learning across three or more topics were categorized as high, students who applied learning across two topics were categorized as medium, and students who applied learning across one topic were categorized as low. Every student in the study applied learning in at least one area, so there was no need to group students with no application. An additional rubric was used to group students again into three categories based on mode. Students who most commonly applied learning across the topics were categorized as high, students who most commonly intended to apply learning across the topics were categorized as medium, and students who most commonly did not do either were categorized as low. The two rubrics were then compared and the same students were categorized as high, medium, and low using both methods. It is important to realize that this composite score is very much dependent on the breadth of students' applications across topics. However, students who applied their learning in more than one way or multiple times relating to the same topic were also likely to have applied their learning across topics. Thus, this composite categorization gives a reasonable way to compare students across high, medium, and low level applying groups.

Application codes and composite application codes were then compared to other items or demographic data that related to the research questions and theoretical framework using cross-tabulation for each health topic taught. For example, the students who reported an application, intention to apply, or did not mention any applications relating to hand-washing were grouped by gender. Other items were also compared to applications including age, grade level, interest in hand-washing, whether or not they made a connection between hand-washing and health in the pre-survey, and their score for questions relating to hand-washing in the post-survey. The coding scheme for interview and post-survey responses is provided in Table 6.

The codes above were emergent from the data, then grouped with similar terms to collapse terms. For example, actions that were coded as “teaching” emerged from students’ comments related to sharing knowledge, explaining how to do something, or telling others about what they had learned. Students’ ages and grade levels were consolidated into groups as well based on the small sample size. For example, instead of looking at each grade level separately, students in grades 5 and 6 were compared to students in grades 7 and 8. This allowed me to better determine patterns, similarities, and differences between groups.

To address research question 3, I used an iterative coding process similar to those applied in questions 1 and 2. Then, these codes were organized in a timeline of events to explore supports and constraints across the duration of the study. For example, cultural factors and cultural bridges (a type of support that will be described in further detail in Section 6.5) were identified from fieldnotes and interview data by creating a timeline with interview codes from earlier questions to explore students’ applied learning. These codes were organized to trace backwards and forwards in time from connections students described making between science and place. For example, Doreen explained learning to connect local practices with what she learned about maintaining a balanced diet when she said, “You can even eat some vegetables like mboga to have a balanced diet” (Doreen, focus group interview) as she described how she applied her learning about maintaining a balanced diet.

Table 6

Coding Scheme for Interview and Post-Survey Responses Relating to Application

Category	Code Word	Description	Example
Application	Intention to apply	Actions with language that suggests future plans for applying what they learned, stated ability to apply what they learned, and/or suggestions for necessary applications	"We can put water guard and water. You know some small kids are going to the latrine and after removing waste, they just don't wash and then they eat something."
	Application	Actions with language that suggests students applied what they learned in the health club	"I taught my sister how to wash his hands… I told her to take soap then with water over the basin, then you smear soap and you rub, rub the hands and in between the fingers. Then you rinse."
Reach	Home	Reach of the identified application or intended application relating to home or family members	"We can also treat water at our house."
	School	Reach of the identified application or intended application relating to school, teachers, classmates, or other students	"Adding the water by the latrines so pupils can wash their hands."
	Community	Reach of the identified application or intended application relating to neighbors, other people in the community, or the local environment	"We can learn how to make, we should organize a day to teach our community about the health club."
Type	Teaching	Type of application or intended application relating to sharing knowledge with others, explaining, showing, or teaching	"I taught my mother balanced diet…I told her how to eat egg or beans for protein."
	Action	Type of application or intended application relating to making a change, providing care, or acting on the environment	"I helped my brother…He was playing with a pile of dirt and he fell… First I washed where the wound was clean and I put some pressure."
Topic	Water*	Code based on interests identified in pre-survey and observations (includes hand-washing, diseases, first-aid, balanced diet, and water)	(topic: water) "I made some changes so that now-a-days we keep our water covered, we want it to be clean."

*Topics were coded with the same scheme developed for the pre-survey, though water is provided as an example from the post-survey responses (see Table 4 for further details on the coding scheme for topic).

This example shows a bridging strategy from local science to school science. Looking across the timeline, I was able to visualize trends in the supports and constraints. These trends were then triangulated with students' reported supports and constraints from interview data.

Chapter 4: Findings on Program Design and Learning Opportunities

Findings are presented in three chapters, each answering one of the four research questions addressed in this study. Chapter 4, the first findings chapter, explains the program design and learning opportunities planned for using the practices of science to improve community health. Next, Chapter 5 presents the ways in which students applied their learning to various areas of health in their homes, school, and community. Then, Chapter 6 describes the factors that influenced students' likelihood of applying their science knowledge toward improving health. Together, these findings chapters demonstrate ways in which science can be connected with place in meaningful ways that serve both students and their local communities.

Findings Chapter 4 answers research question 1) In what ways were learning opportunities planned for using the practices of science to improve community health? Section 4.1 describes how learning opportunities were planned with the community and how this connection continued throughout the health club. Section 4.2 explains the ways in which practices of science and science skills were integrated into health club activities. Lastly, Section 4.3 shows how students' interests were leveraged to plan the curriculum.

The claims in this section are that (1) the health club was planned by community leaders and connected to community needs, (2) instruction was developed around student interests in improving community health, and (3) practices of science were integrated into the health club curriculum. Through this program design, the health club provided specific opportunities for students to connect science education they learned in the health club with the needs and interests of their community, leverage their interests in health toward improving their home, school, and community, and experience science and engineering practices that connected chemistry, physics, biology, and engineering skills with related health concepts. Table 7 provides an overview of activities, place or community-based prior knowledge students accessed, and science and engineering practices that Mme. Atieno and I incorporated into activities. The specific learning opportunities afforded across the health club program design are described in the three sub-sections that follow.

Table 7

Overview of Learning Activities, Examples of Place/Community-Based Knowledge Accessed, Science and Engineering Practices Experienced for Each Topic of Student Interest

Topics of student interest	Activities	Place/Community-Based Prior Knowledge	Science and Engineering Practices
Hand-washing	• Modeled how soap bonds with oil and water • Designed and tested methods for washing hands • Homework: teach someone what you learned	• Hands are washed when eating/cooking, • Home practice uses jug of water poured over hands and into a basin	• Developing and using models
Diseases	• Played germ spreading game • Used F-diagram model to identify how germs spread • Categorized diseases by how they spread • Created and performed doctor dramas on disease symptoms and treatment • Took field trip to local clinic • Played elephant/lion immune system game • Used cartoons and models to discuss how the immune system functions and HIV/AIDS	• Malaria is a disease spread by mosquitos • Mad dogs can spread their disease to other animals • Snails spread sickness in the lake • Medicines and vaccines fight diseases • Doctors can help treat diseases • HIV/AIDS is highly prevalent in community	• Using models • Constructing explanations • Obtaining, evaluating, and communicating information
First Aid	• Identify and discuss when problems require first aid and/or immediate medical attention • Act out how to do first aid in various situations (e.g. how to stop bleeding and how to make rehydration drink for someone who has fever or diarrhea)	• Awareness of situations that could be helped with first aid	• Asking questions and defining problems • Obtaining, evaluating, and communicating information

	• Safely practice giving first aid to each other		
Balanced Diet	• Sort locally bought food into groups • Plan a day of balanced meals to have at home • Discuss health connections • Provide a balanced meal for the school and teach younger students about balanced diet on health day	• Awareness of local foods • Textbook knowledge of food groups and some examples of food in each group • Interest in preventing deficiency diseases	• Obtaining, evaluating, and communicating information
Water	• Walk to lake and discuss local watershed • Map watershed and potential pollutants • Test lake water as a class and interpret results • Test lake water at home and share results in class • Design and test water filters • Design and collect data for school rainwater system	• Understanding of waterborne illness and connections between drinking water and health • Visual awareness of turbidity of lake water	• Planning and carrying out investigations • Analyzing and interpreting data • Designing solutions

4.1 The Health Club was Planned by Community Leaders and Connected with Community Needs

The idea for the health club and for doing educational research was driven by community leaders and this connection with the community guided students throughout the health club. In this study, I intentionally connected the health club with the Namerokamano community beginning with initial discussions for planning. The village elders initiated the health club and this research. Initially, Chief Daniel (pseudonym) contacted a health organization in California for a grant opportunity he had discovered online in the hopes of building the first Namerokamano clinic. Unfortunately, the grant was not applicable outside of the US, but the California health organization fundraised and assisted Namerokamano with the clinic anyway. In their efforts to certify the clinic with the Kenyan government, the nurses and village elders needed a source of clean water and, in turn, networked with engineers in Santa Barbara. When I later traveled to assist an engineering project as their education consultant, I met with the village elders to discuss education needs in the community that would complement health improvements. Chief Daniel, Luke (a school principal), and Thompson (a special education expert who works closely with the health clinic) expressed the need to start a health club. These three leaders hoped that doing so would improve the community's health and sanitation while furthering students' interest in continuing education in science and engineering. I was then invited to visit several schools in the area to meet teachers and students and begin planning the proposed research.

In addition to the chief and village leaders' support to create a health club in the community, a sixth grade student, Oroko, who lived in my home suggested contacting the science teacher at his school (one of the schools where I had been invited by the principal). The student said that this science teacher taught using interactive projects and science experiments so he might be interested in developing experiments for a health club. Oroko was also very interested in participating in the proposed health club. I met with this teacher who provided strong support, introductions to other teachers, and suggestions for the club. He and the principal decided that I should work with the teacher who was responsible for school health, Mme. Atieno, so that we could learn from each other and co-instruct the club.

Mme. Atieno was very enthusiastic about starting a health club. In discussions with her, I learned that she had been intending to develop curriculum around health topics after participating in a school health workshop and already had many ideas for the topics that would be relevant to her students. We discussed the most appropriate age group based on safety concerns associated with doing science experiments and proficiency with English. She selected 20 students in grades five through eight who had demonstrated an interest in science and health. Due to the high level of interest among the students, she later decided to expand the group to about 30 (the size of a typical class in their school) so that more students could participate.

As evidenced by the events described above, it was the local leaders, teachers, and students who initiated and drove the program planning process. The community-driven aspect of the health club played a strong role in the feasibility and sustainability of the program as well as students' applied knowledge and resulting behavior changes, as will be explored in the sections that follow. Figure 11 below shows the many ways that I interacted with the community and the community interacted with the health club.

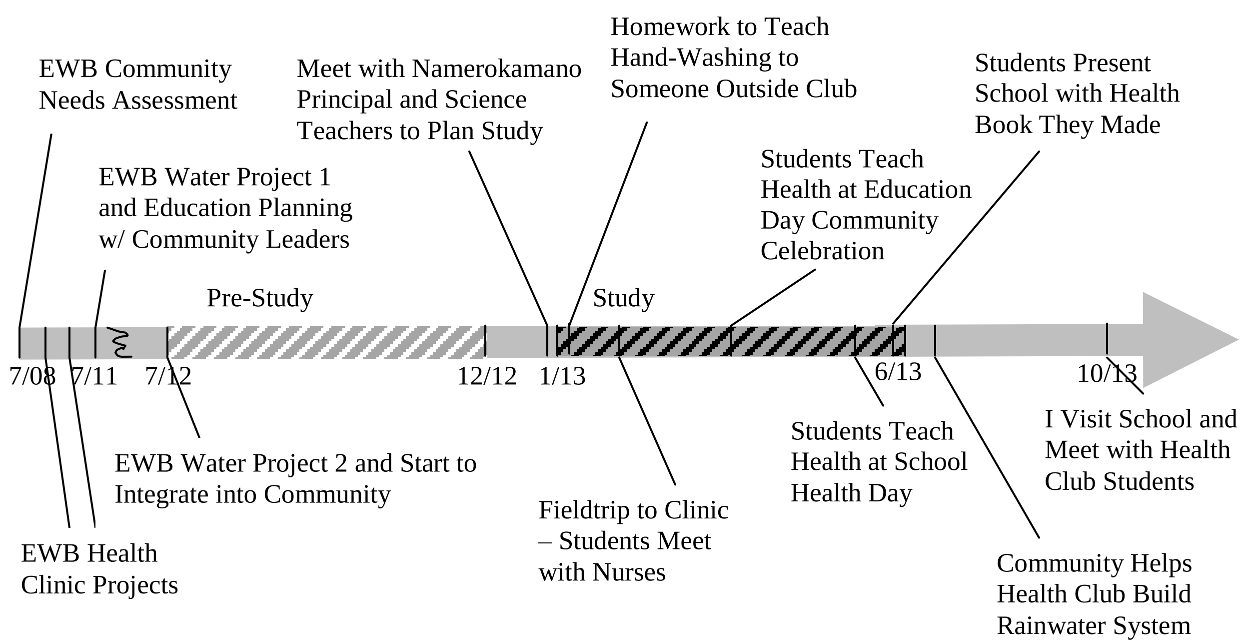


Figure 11. Timeline of community interactions between August 2008 when Engineers without Borders (EWB) first came to do a community needs assessment and October 2013 when I returned to visit the community and school. This research study spans the timeframe from January 2013 to June 2013.

After the health club began, community interactions became a driving force of the curriculum. The principal asked health club members to take on responsibilities for school hygiene and invited them to teach what they had learned at school functions. For example, the principal asked for volunteers from the health club to show ministry officials how to properly wash their hands before lunch was served on Education Day. Mme. Atieno and I also guided students to make a book for their classmates. They designed a health textbook and distributed copies at a school event. Students even recruited their families to help build a rainwater catchment system. These two-way interactions with the health club and the community served to initiate connections between students and their community, as well as positioned the students as having something of value to learn and share in return.

4.2 Instruction was Developed around Student Interests in Improving Community Health

Instruction was guided by students' interests in health and health needs they had identified. Mme. Atieno and I leveraged students' interests in improving health in their homes, school, and community in the health club from the first day of instruction. In a follow-up interview with Mme. Atieno, she noted that the key for the success of the health club came largely from specific health issues being selected mainly by the students. The club's overarching goals were discussed and decided upon by the teacher, and school principal and me in advance. These goals included (1) fostering student's engagement, interest, and motivation in science; (2) improving the health of participating students and the school; and (3) preparing students to be leaders in their community. Then, the students selected health issues they were interested in learning about, and these overarching goals and students' interests drove the lesson-planning for each health club meeting.

On the first club meeting, the students were asked to take a pre-survey. The final question on the survey asked students, “What do you want to learn most about health?” Of the total number of responses for students who completed both pre and post-surveys (N=20), Table 8 shows the frequencies and percentages of students who were interested in that category. Over half of the students wrote about diseases (60%), either generally such as saying they wanted to learn how to treat diseases or mentioning specific diseases such as tuberculosis as a topic they wanted to learn. HIV/AIDS was coded separately from diseases since students who listed it separated their comments about HIV/AIDS from other diseases though these codes could arguably be collapsed into further interest the students found in diseases. Hand-washing was the second most listed code with 40% of students. First aid also had substantial interest with 35% of the students wanting to learn skills relating to first aid.

Table 8

Student Interests from Pre-Survey Free Response Question, “What do you want to learn most about health?” for the 20 Students in the Club Who Completed Both Pre and Post-Surveys

Topics Students were Interested in Learning	Frequency (N=20)	Percentage (N=20)*
Diseases	12	60%
Hand-Washing	8	40%
First Aid	7	35%
Water	3	15%
Balanced Diet**	0	0%

*Percentages represent the percentage of students with a response relating to each topic and do not sum to 100% since many students responded with more than one interest.
**Interest arose from discussion, not surveys

After they finished writing, students were led in a discussion about their interests. Mme. Atieno asked students to volunteer some of their ideas. Then, she asked them to think about what health problems they have seen in their homes and school and what they wanted to learn about those problems. Excerpt 1 below is from fieldnotes taken on the first day of the health club. It is included to show how students discussed their initial health interests and community health needs.

Excerpt 1: January 22, 2013 Fieldnotes

> We [Mme. Atieno and I] made a list [of health topics students were interested in learning about from in-class conversations] on the board. There was also a question at the end of the survey that asked the same thing so I had two ways of getting at this information. The students started getting more comfortable with their suggestions though and hit on some topics they really wanted answers to. Here is the list they came up with [in response to a discussion about the health needs in their community]:
>
> a) Hygiene and sanitation
>
> b) How can we help people who have fainted?
>
> c) How [do] we get HIV/AIDS? How can we prevent HIV/AIDS from spreading?
>
> d) How can we help when someone takes poison?
>
> e) What can we do for people who have AIDS?
>
> f) Why is cholera so dangerous?
>
> g) How [do] we get cancer?
>
> I left most of their questions open and told them we would try to learn about as many of these things as we could during this term. I also told the students

> that scientists are still researching some of these things and that we would also do some science research to help us learn and answer our questions.

The students began with general ideas about health as it relates to hygiene and sanitation. One student quietly raised her hand to ask about how we can help people who have fainted. In a later meeting, the students explained that their peers faint often especially during sports or when they have *homa* (a cold or flu). Students also asked many questions about HIV and AIDS throughout the first health club meeting. At the time of the study, their region had the highest percentage of people with diagnosed HIV/AIDS in all of Kenya. A nurse at the clinic reported that about 27% of the community was living with HIV/AIDS the previous year. Poison was a concern that some students had about younger siblings. Chemicals such as petrol, battery fluid, transmission fluid, and cleaning products are often stored in used soda bottles. Some students worried about keeping these away from younger siblings and wondered what they should do if their siblings accidentally drank poison. Students who lived closer to Lake Victoria also had frequent experience with waterborne illnesses. There had been a cholera outbreak in the previous school year. Students knew the disease shared symptoms with other water-related illnesses, but were not sure what made cholera one of the illnesses they saw and heard of often.

After the initial health club meeting, I asked Mme. Atieno about how she thought the meeting went and what goals and lessons might work for the club. We discussed what the students reported wanting to learn about health and the feasibility of each suggestion using our notes from the class and the students' surveys. She liked the plan for developing a curriculum directly from the students' questions and suggested that we start with personal hygiene. Four students listed hand washing as something they want to learn so we decided it would be a good first topic to address. I told her that I had some activities for hand-washing we could try so we decided on that. The hand-washing activity used a constructivist approach to allow students to make observations and design models about how soap works in bonding water and oil. They then use the model and experimentation to design a method for hand-washing. Mme. Atieno said she was familiar with hands-on teaching practices and that they always interested the students, but mentioned uncertainty in how to integrate these practices into lessons. Because of this, I planned the first lesson and we planned the others together. Other lessons allowed students to map their watershed to examine possible pollutants into the lake, explore what medical first aid response can do to help someone who has fainted or is bleeding, and examine conditions in which bacteria can grow and thrive. These lessons offered key practices of science and conceptual knowledge that related to students' health interests and could be used to design solutions to health issues in the community.

4.3 Practices of Science and Engineering were Integrated into the Health Club Curriculum

Practices of science and engineering were integrated into the health club curriculum so that students could see science as actions that can be used in real world contexts. Mme. Atieno and I integrated science and engineering practices that connect chemistry, physics, biology, and engineering skills into the health club curriculum so that students could learn connections between these practices and their interests in health. The health club curriculum focused on integrating science and engineering practices since these allow science to be taught as performance, which Le Grange (2007) suggests helps students make science more situated in real life context.

Throughout the health club, students had opportunities to ask questions and define problems; develop and use models; construct explanations; obtain, evaluate, and communicate information; plan and carry out investigations; analyze and interpret data; and design solutions. These practices were consistent with those suggested by the Next Generation Science Standards (NGSS Lead States, 2013) and the Kenya National Syllabus (Kenya Literature Bureau, 2009). I used both of these in the curriculum design since I was more familiar with the Next Generation Science Standards, but still wanted the curriculum to be locally relevant. In the Kenya National Syllabus, students in primary school are expected to learn scientific skills including modeling, investigating/experimenting, and communicating among others. While students selected the health topics they were most interested in learning, lessons were designed to integrate science and engineering practices as well as to connect with the Kenya National Syllabus content and skill-based learning objectives (akin to US state standards). In standard eight (the equivalent of eighth grade in the US), students in Kenya are expected to learn science content about the human body, health, water, the environment, and foods and nutrition among other concepts (Kenya Literature Bureau, 2009). Students were able to bring in their school and textbook learning from content areas through their interests, questions, and discussions, while Mme. Atieno and I worked to connect these content areas to relevant science and engineering practices through health club activities. The book, *Where there is no doctor: A village health care handbook* (Werner, Thuman, & Maxwell, 2011) and the Peace Corps *Life Skills Manual* (Callahan, 2001) were used as resources to help connect science practices with relevant health content for curriculum planning. Table 9 below shows the NGSS practices and Kenyan Syllabus science skills for students to learn by the end of eighth grade.

Science and engineering practices were integrated into health topics students were interested in learning. For example, *developing and using models,* listed in Table 9 above, was integrated into a three-week unit on hand-washing. On the first lesson of this unit, students observed one glass that contained oil and water, drew what happened just after the oil and water were mixed and then a few minutes later when the two liquids settled. The students were then asked to add liquid soap to the oil and water, observe any differences, and draw a model that explains the role of soap when the three liquids are mixed. Students discussed their models in groups of 4-5 and came to consensus in their groups. Two students drew their models on the board. In a whole-class discussion, the students decided that the two models were similar and could be combined. They agreed that the soap kept the oil and water from separating. After agreeing on a model that shows how soap bonds with water and oil, students were asked to use the model to design a method for hand-washing. Their method was tested with oil and dirt and students experimented with methods until each group had a written method that removed as much oil and dirt as possible. All methods students developed involved soap. Mme. Atieno then reviewed concepts with the students and asked them to talk about why we need soap to wash our hands. This lesson on hand-washing allowed students to explore the science practice of *developing and using models* and provided an introduction to the science practice of *planning and carrying out investigations.* Moreover, this practice was directly applied to students' initial interest in learning about hand-washing and why soap is important in hand-washing.

Table 9

Science and Engineering Practices and Skills Included in the Next Generation Science Standards (NGSS) and Kenya National Syllabus for Students in Standard/Grade Eight as Well as Related Examples from the Health Club Curriculum

NGSS Science and Engineering Practices (NGSS, 2013)	Kenya National Syllabus Science Skills (Kenya Literature Bureau, 2009)	Examples from Health Club Curriculum
Asking questions (for science) and defining problems (for engineering)	Communication	Students identified health needs in their community and used those needs to develop testable scientific questions.
Developing and using models	Modeling, drawing and labeling	Students developed, drew, and labeled models for interactions between oil, water, and soap and used their models to construct explanations for how soap works and develop methods for hand-washing.
Planning and carrying out investigations	Experimenting/ investigating, manipulation, controlling variables	Students collected water sources, and used bacteria growth plates to grow visible colonies of bacteria overnight to compare different water sources and/or treatments.
Analyzing and interpreting data	Identification, recording, comparison	Students analyzed bacteria growth from water tests to identify health effects from untreated lake water and make comparisons between other water sources and/or treatments.
Using mathematics and computational thinking	Measurement, Tabulating	Students measured school roofs and calculated rain water potentially collected for various dimensions and engineering designs.
Constructing explanations (for science) and designing solutions (for engineering)	Classification	Students classified locally available food into different food groups and constructed explanations for how to maintain a balanced diet at home.
Engaging in argument from evidence	Communication	Students engaged in argument from evidence collected in testing water filters they had designed.
Obtaining, evaluating, and communicating information	Observation; Communication	Students used health books, interviews with local nurses, class notes, and observations to design a health textbook communicating important concepts to other students.

Chapter 5: Findings on Science Learning Applied to School, Home, and Community

This section answers the research question 2) In what ways did students apply science and engineering practices learned from the health club in their school, homes, and community? Applied learning is a critical aspect of this study for two reasons. First, from a science education perspective, place-based learning involves both integrating place into the classroom and applying learning back toward place. Second, from a health education perspective, applied learning is a possible intervention strategy for community behavior change. In order to explore students' applied learning toward improving their place and initiating community health improvements, this chapter examines the ways in which students applied their science learning to their school, home, and community. Sections 5.1 through 5.5 describe students' applied learning relating to students interests that became the curricular units. These include: hand-washing, disease prevention, first aid, balanced diet, and water management. Table 10 and Figure 12 compare students' applications for each of these areas. Then for each, the ways in which students applied their learning are described with transcripts providing specific examples for understanding students' specific applications from their perspectives. Lastly, in section 5.6 I look across topics to discuss how students applied learning in different contexts, interacting with different people, to initiate behavior changes.

Table 10

Number of Students who Applied and Intended to Apply Learning in Each Health Topic (Curriculum Unit)

Topics	Applied (N=20)	Intended (N=20)	None (N=20)
Hand-washing	18	2	0
Water	11	7	2
First Aid	11	7	2
Diseases	7	10	3
Balanced Diet	4	8	8

Note. Students who both applied learning and had additional intentions to apply learning for a given unit are included in the applied category.

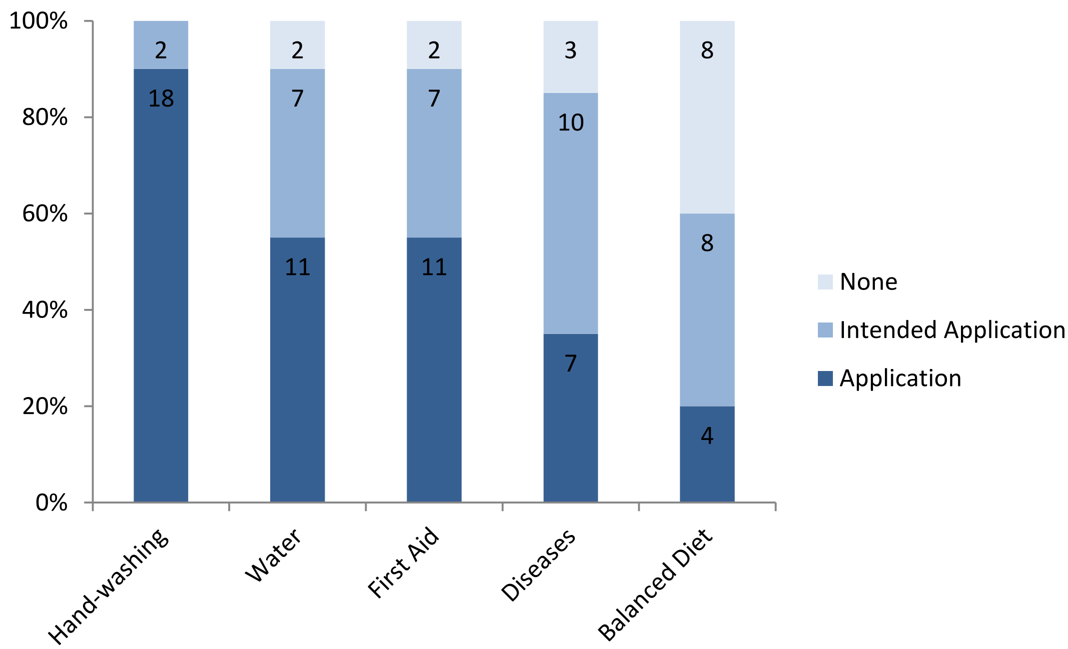


Figure 12. Percentage of students applying what they learned related to each topic. Numbers in each shaded section show the frequency counts of students who applied their learning (dark shade), had intentions of applying learning (medium shade), or had neither applications nor intentions (light shade) in each topic for the 20 health club students who were interviewed and surveyed.

As will be discussed in more detail below, learning related to hand-washing was the topic that was most commonly applied by students outside the health club. Though, 80% of students at least *intended* to apply their learning across the areas of disease prevention, first aid, and water in the future. Additionally, students had more intentions than applications for the area of disease prevention and balanced diet with few students applying their learning in this area. Sections 5.1 through 5.5 below expand on each of these areas to shed light on the ways in which students applied or intended to apply their learning.

In an effort to compare students' application of learning across health topics with their perspectives on the topic prior to the health club, I examined students' pre-surveys for their interest and any connections they made between each topic and health. It is important to note that just because a student may not have indicated an interest or connection, does not mean they did not have an interest or understand a connection for that topic. Their interests and connections to health were determined from open-ended questions where students could consider any interests in health or anything that helped them stay healthy. Looking at the interests and connections that students did indicate prior to the health club does provide insight into their focus in health. Table 11 shows the number of students who indicated an interest or connection to each health topic prior to participating in the health club. The topic of diseases was the most frequently reported interest and connection students made with health. Pre-interests and pre-connections will be discussed further in the Chapter 5 sections that follow.

5.1 Hand-washing

In the health club, students learned science and engineering practices that related to hand-washing, diseases and how they spread, first aid, balanced diet, and water. Of these, hand-washing was the topic the greatest number of students applied outside of the classroom.

Table 11

Number of Students who Demonstrated Pre-Interest and Pre-Connection with Health for Each Health Topic (Curriculum Unit)

Topics	Pre-Interest (N=20)	Pre-Connection (N=20)
Hand-washing	8	11
Water	3	15
First Aid	7	1
Diseases	12	20
Balanced Diet*	0	0

*Interest arose from later discussions, not surveys

Students were provided opportunities to learn about chemistry and hand-washing by (1) modeling how soap bonds with oil and water, (2) designing and testing methods for washing hands, and (3) having a homework assignment to share their method with others. Specifically, 18 of the 20 students in this study reported teaching what they had learned about hand-washing to others, especially family members. Hand-washing was also a chapter students included in the health book they made. Figure 13 below shows the hand-washing chapter of this health book. The group of students who wrote this chapter wanted to show the method they created and hoped other students would learn. The image also shows a connection the group made to a song they had learned in school and to materials available in their homes. Table 12 lists the ways in which students applied what they learned about hand-washing (further details of these applications are provided in Appendix E).

Figure 13. Hand-washing chapter of text book that students made and distributed to every classroom showing the method for hand-washing created by a group of students with pictures showing locally-relevant practices and a song they had learned in school.

Before the health club, about half of the students (11 students) recognized the connection between washing hands and preventing the spread of disease (see Table 13 below). When most children wash their hands in Namerokamano, they first help any adults present by pouring water from a jug over their hands and into a basin. Then children wash their own hands in the basin of the water that collected when the adults had washed their

Table 12

List of the Ways that Students Applied or Intended to Apply Learning about Hand-Washing

Hand-Washing Applications and Intended Applications	
Wash hands…	With soap or running/pouring water Before eating/after using latrine
Teach hand-washing…	To family To classmates/teachers To community
Provide water for hand-washing	

hands. Children most often washed their hands before and after eating. In an open-ended question on what students wanted to learn about health, eight of them mentioned hand-washing. The school principal and Mme. Atieno also mentioned increasing hand-washing in the school as a goal they hoped they could achieve through the health club.

Through the hand-washing health club activities (refer to Chapter 4 above for more details on health club activities and learning opportunities provided), those students who had a low understanding were provided opportunities to make a connection between health and hand washing, and those who already had a basic understanding had the opportunity to develop this connection further by developing a model of the mechanism for how soap works to remove germs. After learning the chemistry of how soap works to bond water and oil molecules, students began to recognize the importance of using soap as evidenced by their reported applications. Students were asked to design a method for washing their hands to have the greatest chance that oil with germs trapped in it will bond with water and move off their hands. In doing so, students discussed the need to smear soap, rub the hands, and also to use water that is free from other people's germs so as not to reintroduce new germs. Students incorporated many of the concepts from the chemistry modeling activity into their methods for hand-washing and it is these methods that they reported teaching others. In addition, some students connected teaching hand-washing with an understanding of diseases that spread from contact with fecal matter. These students mentioned teaching their families not only how to wash their hands, but encouraging them to wash their hands especially after using the latrine.

Table 13 shows the cross-tabulation of students who made a prior connection between hand-washing and health with whether or not they applied their learning. Whether or not students had made a connection between hand-washing and health before the club did not seem to influence their likelihood of applying their learning. In fact, students often reported teaching specific connections between hand-washing and health to others in order to explain when it is important to wash hands.

Regardless of whether an individual student expressed interest in hand-washing prior to the health club, most appeared to enjoy the chemistry modeling experience and shared what they had learned with others (see Table 14). For this unit, students were directed to share the hand-washing method they had created with others in a homework assignment. Students were asked to teach at least one person how to wash their hands using what they had learned from the chemistry inquiry and hand-washing activity. Most students went well beyond teaching one person for this assignment. Two students even mentioned that they set up the chemistry modeling experiment for their siblings rather than just telling them the method for hand-washing. Students were less likely to teach hand-washing in the larger community, but most were confident in their ability to teach hand-washing at home to their

Table 13

Pre-Connection Between Hand-Washing and Health Compared to Application, Intended Application, and No Application

Hand-Washing	Students indicating application	Students indicating intention to apply	Students not indicating application or intention	**Total**
Students reporting prior connection between hand-washing and health	9	2	0	**11**
Students not reporting prior connection between hand-washing and health	9	0	0	**9**
Total	**18**	**2**	**0**	**20**

siblings and parents as well as to their peers (and even teachers) at school. In Case One below, two students reflect on changes in their hand-washing practices based on the science they learned in the health club.

Table 14

Pre-Interest in Hand-Washing Compared to Application, Intended Application, and No Application

Hand-Washing	Students indicating application	Students indicating intention to apply	Students not indicating application or intention	**Total**
Students reporting prior interest in learning about hand-washing	7	1	0	**8**
Students not reporting prior interest in learning about hand-washing	11	1	0	**12**
Total	**18**	**2**	**0**	**20**

Case one: teaching younger siblings how to wash their hands with pouring-water and soap. While adults in Namerokamano wash their hands in water poured from a jerry can over a basin that catches the water, most children wash their hands in the water left in the basin. If an adult or another child is sick, then it is very easy for germs to spread via the water in that basin. Textbooks teaching hand-washing practices typically show a tap with water flowing from it and tell students to wash their hands with soap and running water. In Namerokamano, there is no plumbing and taps are typically just used near water sources for filling up containers with water to take home. Taps are not readily accessible for washing hands. Thus there was a disconnection between home practices and what students knew from their school textbooks. Learning that soap serves to bond oil and oil-trapped germs with water and that pouring water uses gravity to help remove those molecules, the students were able to think of ways to bridge the disconnecting concepts they had previously learned for washing hands. In Transcript 1, students discuss learning that running water does not necessarily need to be from a tap and that the practice children use to wash hands in the basin might not be the best option.

Transcript 1

Line	Speaker	Speech
1	David:	[Before the health club] I just knew the meaning of hand-washing
2	Researcher:	So what was new about hand-washing for you?
3	David:	The reasons for doing hand-washing
4	Researcher:	So, the reasons for doing hand-washing were new for you?
5	David:	[nods]
6	Researcher:	What about you [Paul], what was new for you about hand-washing?
7	Paul:	Using the running water
8	Researcher:	Oh, the running water, the idea that it is pouring
9	Paul:	Because I was thinking you can just use whatever which is on the floor
10	Researcher:	Like especially for young kids, I see them using that one. So, now do you use running water when you wash?
11	Paul:	Yes, we pour [uses hands to show pouring from a jug]

5.5 Water

Access to clean water is critical to alleviating poverty and improving health in developing countries (WHO, 2007; World Water Assessment Programme, 2009). To improve access to clean water, developing countries need to integrate knowledge of science, technology, and society (Gleick, 2003). Understanding water and using this knowledge to improve access includes understanding the environment and how the water flows; understanding the connection between water and human health; and developing the skills necessary to use technologies that will improve access without compromising the environment, health, or local culture (Montgomery & Elimelech, 2007). Because of water's importance to all of the other areas of health included in the health club, including washing hands, preventing diseases, first aid (hydration), and food, Mme. Atieno and I intentionally made it a strong focus of the curriculum. In the health club, students had the opportunity to learn about water management, storage, and treatment toward improving access to clean water. Students had the opportunity to (1) walk as a class to the lake while discussing water flow in their local watershed, (2) make maps of the watershed and potential local pollutants, (3) collect water samples at the lake, (4) grow bacteria from the lake water samples and interpret the results, (5) volunteer to take water testing equipment home to perform additional experiments and share results with the club, (6) design and test water filters, and (7) design and collect data for a school rainwater system. Figures 14 and 15 below show two such opportunities.

Figure 14. Health club members testing out the water filter they made.

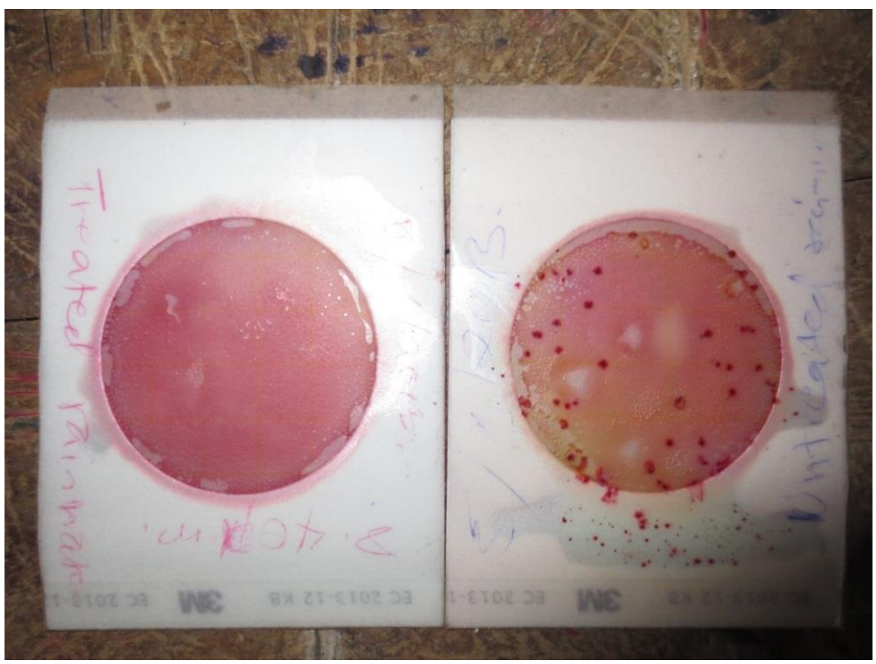


Figure 15. Water quality data from a student's home water tests comparing treated and untreated rainwater after 24 hour incubation period. Red dots represent colonies of fecal coliform indicator bacteria found in 100mL of water sampled.

Students both applied and taught others much of what they learned about science relating to water. In cases where students only intended to apply their learning, it was often because students had grand ideas for their community in the future that may require more autonomy and funding. Most students specifically discussed the importance of having access to clean water in their community and wanting to help make improvements. Students volunteered to take bacteria testing materials home to do their own experiments. They were guided to ask a testable question comparing two water sources, treatments, or storage techniques. About half of the students in the health club chose to do home water experiments. They then shared their results with the rest of the club and discussed the implications. Even two students, Teni and Brenda, who did not test water themselves used the evidence from their peers to teach their family the implications. They talked in a health club meeting about being surprised that rain water still contained bacteria in their friend's test so they should still treat rainwater when using it for drinking or cooking. Table 15 lists the ways that students applied or intended to apply their learning about water.

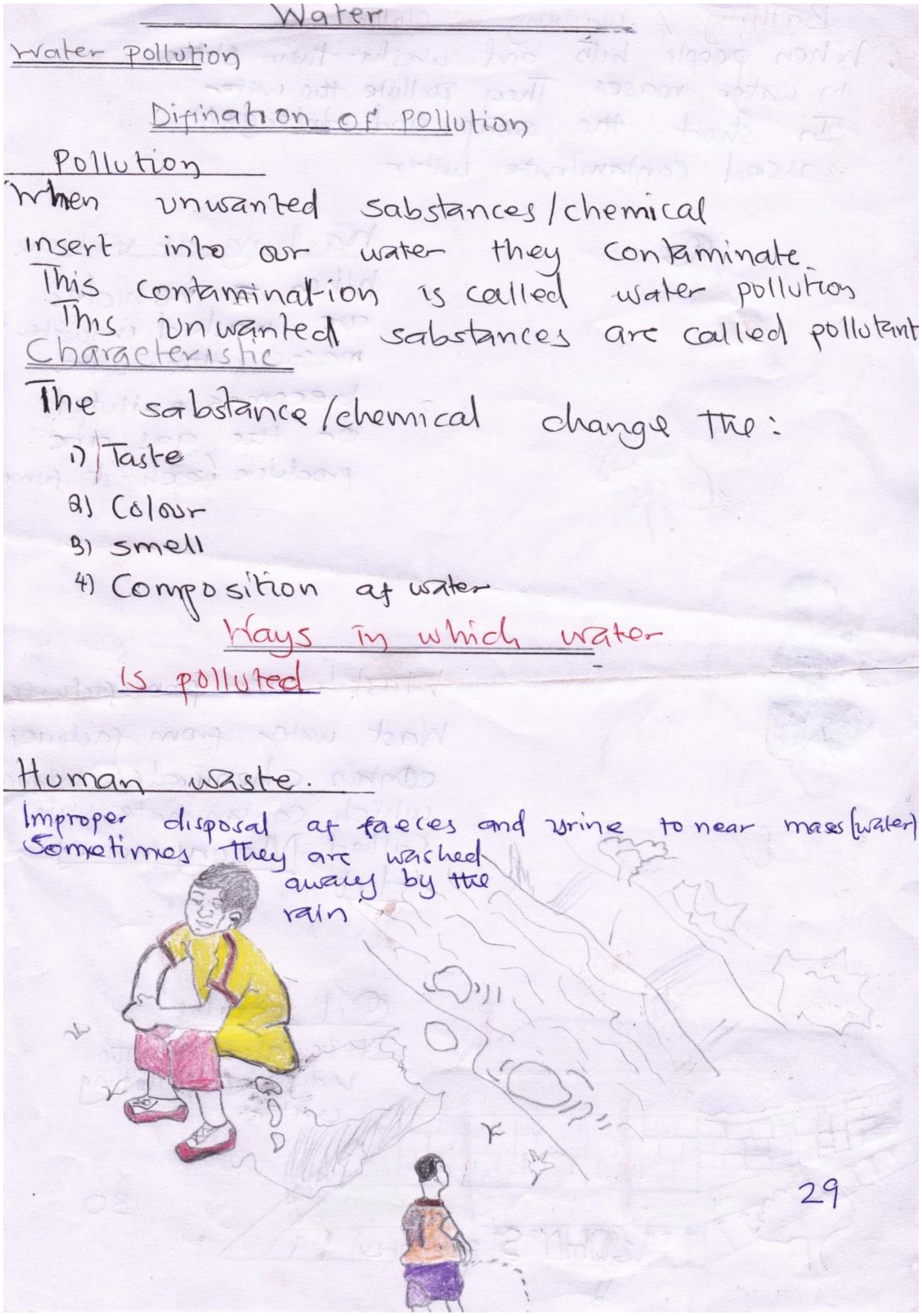
One student, Jeff, showed substantial interest in the practices of science related to water including mapping the pollutants in the watershed and testing water for bacteria. He did multiple water tests and shared his results with his older brother who teaches high school. Working with two other students, Jeff drew diagrams showing issues in their local watershed (see Figures 16 and 17) that highlight discussions from the health club walk and mapping exercise as well as connections Jeff made between the science and his own observations about health behaviors.

Table 15

List of Ways That Students Applied or Intended to Apply Learning about Water Treatment/Storage

Water Concepts	
Water treatment, testing, and storage…	Treat water for drinking/cooking
	Provide treated water
	Label water/place sign
	Cover water
Waste water/watershed management…	Build latrines near lake
	Pick up/do not throw rubbish
Teach water testing and treatment (e.g., not to drink untreated lake water)…	To family
	To classmates/teachers
	To community

Half of the students in the study (9 students) made an explicit connection to water when asked open-ended questions about health in their pre-survey. This shows that these students were aware of and demonstrated an understanding that water has an influence on health. Table 16 below shows students' pre-connections between health and water. Despite the large number of students making such a connection, only 1 student listed water as a health topic of interest to learn. Even though only one student mentioned an interest, most who did not demonstrate a pre-interest on their surveys still applied their learning about water. Table 17 shows the pre-interest students demonstrated in learning about water compared to their application and intended application to apply their learning.


Water

Water pollution

Difination of pollution

Pollution

When unwanted sabstances/chemical
insert into our water they contaminate.
This contamination is called water pollution
This unwanted sabstances are called pollutant

Characteristic

The sabstance/chemical change the:
1) Taste
2) Colour
3) smell
4) Composition of water

Ways in which water is polluted

Human waste.

Improper disposal of faeces and urine to near mass(water)
Sometimes they are washed away by the rain

29

Figure 16. Jeff's drawings for the health club book chapter introducing water pollution for the chapter on water.

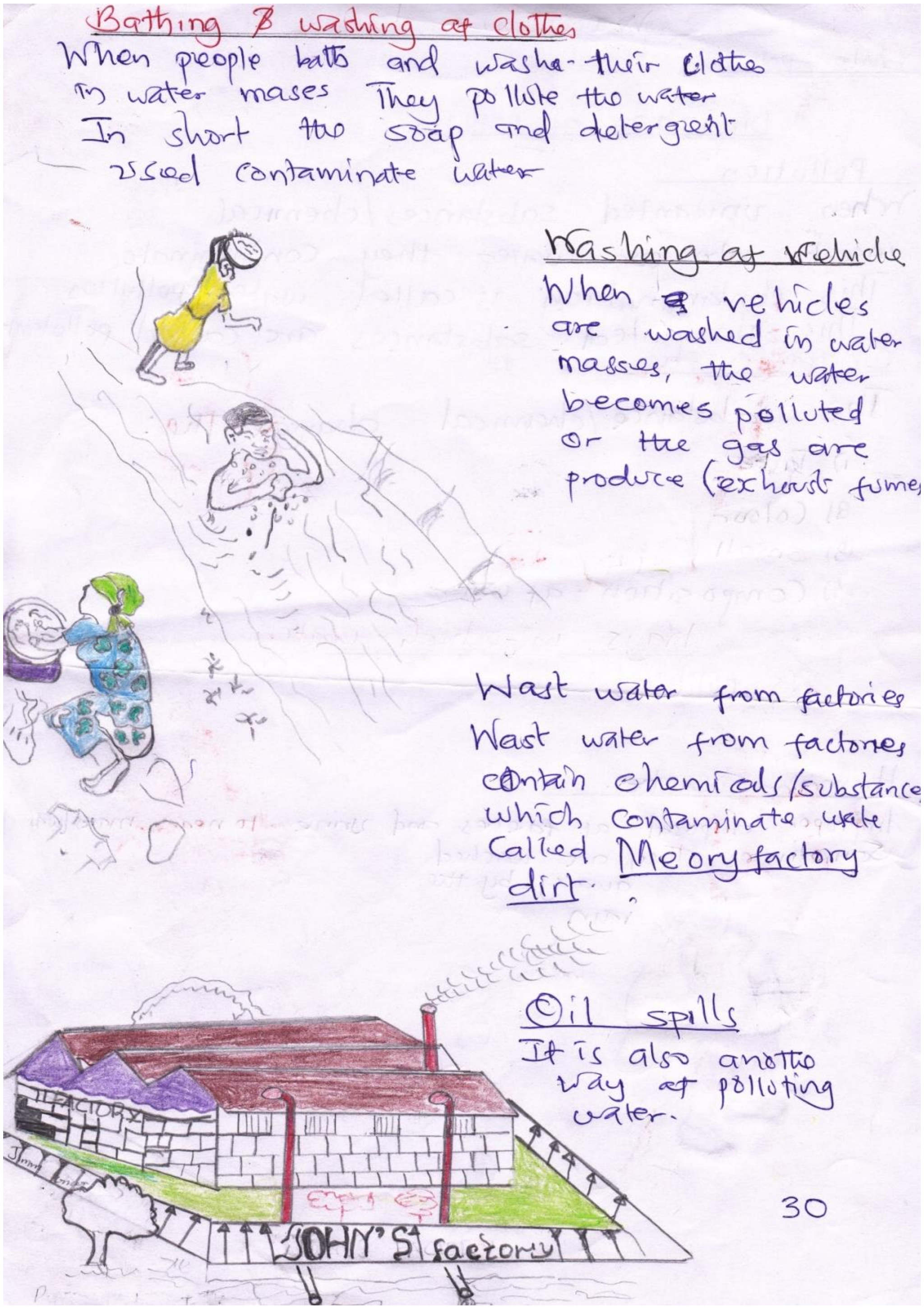


Figure 17. Jeff's drawings for the health club book chapter on water showing additional potential pollutants to water sources.

Table 16

Pre-Connection Between Water Treatment/Storage and Health Compared to Application, Intended Application, and No Application

Water	Students indicating application	Students indicating intention to apply	Students not indicating application or intention	**Total**
Students reporting prior connection between water and health	9	5	1	**15**
Students not reporting prior connection between water and health	2	2	1	**5**
Total	**11**	**7**	**2**	**20**

Table 17

Pre-Interest in Learning about Water Treatment/Storage Compared to Application, Intended Application, and No Application

Water	Students indicating application	Students indicating intention to apply	Students not indicating application or intention	**Total**
Students reporting prior interest in learning about water	1	2	0	**3**
Students not reporting prior interest in learning about water	10	5	2	**17**
Total	**11**	**7**	**2**	**20**

Case two: improving community water sources and future access to clean water. While half of the students in the study (11 students) directly applied what they learned about water, several students discussed future ideas they had for improving water availability and quality. Such ideas demonstrated that students hoped to apply their learning in far reaching ways for their own communities and others who they felt had an even greater need. The conversation in Transcript 2 below highlights students' attempts to solve a complex and difficult problem facing many communities in Kenya. While Danny, Jeff, Jarrod, and Nasir felt they were capable of making some improvements, they recognized that others would take more time. The group did suggest some short-term improvements they could make to their lake that would help improve water quality in the future and things they could do to ensure that their families drank clean water at home. Transcript 3 below highlights a similar conversation where students discussed the importance of access to clean water.

Transcript 2

Line	Speaker	Speech
1	Researcher:	Any other ideas about how what you learned can help? What about the larger community? Can it help the larger community of [Namerokamano] at all? How can what we learned help the larger community of [Namerokamano]?
2	Danny:	You can teach those people near the lake there.
3	Jeff:	They are removing their waste there.
4	Jarrod:	Just go there, we'll start collecting the rubbishes and we'll burn them down there. And we can remove those so that lake water can be cleaner and treated for drinking.
5	Jeff:	It is too dirty. It cannot be treated for drinking.
6	Jarrod:	You can go to the lake water and place a certain sign and you treat it very well and keep it very clean, then it can be someday better to drink the water.
7	Researcher:	You bring up a good point. It is very difficult to treat the whole lake like that. But I mean some of those things you suggested can help make it—
8	Jarrod:	You can remove dirty water ourself.
9	Researcher:	You can prevent it from getting even more dirty and like you said you can take some of it for treating drinking water. Any other ideas for how?
10	Nasir:	It is just that we can collect water and put a tank and then people can come for treated water.
11	Jeff:	Yeah, I've shared too. Me, I've told my brother there who is a teacher. He used to take water and just drink it and just say that this water has no bacteria, the water is just too clean. I tell him no, the water is not very much safe. I went and tested it. So let us treat and we see. And then I treated just the water there. I took some treated and untreated water from there and then I put that chemical on it and leave it for some time. And I showed that now we can see the difference between the treated and untreated water. So he told me oh, that is too good.

In conversation in Transcript 3, Matthew talked about the importance of treating drinking water and Jacob described future plans to help Turkana, a high poverty region in the far north of Kenya where limited resources often lead to violence. These young students (Matthew was 12 and Jacob was 10) may not have made as many strides as the older health club students in applying their learning directly, but they demonstrated an understanding of the importance of doing so in the future. The differences in students' ages and their application of learning will be discussed later in Chapter 6.

Transcript 3

Line	Speaker	Speech
1	Researcher:	What was your favorite? What did you like the most?
2	Matthew:	water treatment and hand-washing.
3	Researcher:	Water treatment and hand-washing? So, why did you like the water treatment?
4	Matthew:	I like water treatment because some people are just drinking water without treating and if you drink water without treating, you can get a disease.
5	Researcher:	Ah, so you think that it is very important?
6	Matthew:	If you treat, you can live.
7	Researcher:	And what about you, you were going to say something about water treatment?
8	Jacob:	I can start water treatment at someplace like Turkana. Sometimes they don't even have water to drink and cook their food. They are just not getting it.
9	Researcher:	You see that on the news sometimes? So, what would you like to do someday for the people of Turkana?
10	Jacob:	I can help with water pump so if it is season of draught, such water will not be taken.
11	Researcher:	That would be a big help to them.
12	Jacob:	Yes, so that they don't die.

5.3 First Aid

Students had several questions related to how they could help someone who is hurt or ill through an understanding of science and first-aid. Many students also hoped to have future careers as doctors or nurses and saw the importance in learning how to provide early care and knowing when to take someone to the clinic or hospital for treatment. In the health club, students were provided opportunities to learn first aid by, (1) practicing and acting out in pairs what to do for various situations (e.g., when someone has a high body temperature/fever, has lost fluids/ is dehydrated, is bleeding, is poisoned, is bit by a snake or spider, is choking, has lost consciousness, or is not breathing, (2) applying first aid in real life when one health club member got a nose bleed, (3) discussing the role of first aid and putting on mini dramas for what to do in various situations and when to go to the doctor. In addition to these opportunities, students found many other ways to apply their first-aid learning outside of the health club.

Students were able to apply first aid in many different contexts. The most surprising was the health club's role in establishing the first sports emergency medical treatment (albeit unofficially) in the region. Two students noticed that their peers often fainted, twisted ankles, or tripped and were cut during sports games and track meets. They asked Mme. Atieno and the principal if they could come to the games to provide first aid. They were granted permission and then attended most of the games. They moved players who passed out from the heat into the shade and made them rehydration drinks. They wrapped ankles and instructed students, even those on other teams, to rest and see a doctor if it felt worse later. The students were able to apply their health skills directly to these sport games and reported that it gave them the confidence to use these skills in other contexts should the need arise. While there were not always chances for all of the students to use first aid, most reported feeling comfortable doing so and intended to apply their learning in the future. Table 18 shows the ways students applied what they had learned about first aid toward improving home, school, and community health.

When asked how to stay healthy in their pre-surveys, most students did not refer to first aid or treating injuries; yet, some (7 students) showed an interest in learning first aid.

This interest was brought up in early conversations the club members had about health and community needs which is evidence that though students did not specifically mention the connection, they saw the need for using first aid in their community. Table 19 compares the pre-connection students demonstrated between first aid and health with whether or not they applied their learning. Table 20 shows the comparison between pre-interest and application.

Table 18

List of the Ways Students Applied or Intended to Apply Learning about First Aid

First Aid Concepts	
Apply first aid…	Bleeding
	Nose bleeding
	Fainting
	Fever
	Choking
	Dehydration
Teach first aid (e.g., Heimlich maneuver - 4, reducing fever, making rehydration drink)…	To family
	To classmates/teachers
	To community

Table 19

Pre-Connection Between First Aid and Health Compared to Application, Intended Application, and No Application of First Aid

First Aid	Students indicating application	Students indicating intention to apply	Students not indicating application or intention	**Total**
Students reporting prior connection between first aid and health	1	0	0	**1**
Students not reporting prior connection between first aid and health	10	7	2	**19**
Total	**11**	**7**	**2**	**20**

Table 20

Pre-Interest in First Aid Compared to Application, Intended Application, and No Application of First Aid

First Aid	Students indicating application	Students indicating intention to apply	Students not indicating application or intention	**Total**
Students reporting prior interest in learning about first aid	5	1	1	**7**
Students not reporting prior interest in learning about first aid	6	6	1	**13**
Total	**11**	**7**	**2**	**20**

Case three: knowing how to help younger siblings by providing first aid. In this case, Jacob described how he had already used first aid in his home to help his brother. Though he had not had an opportunity to apply first aid in other contexts, Jacob was confident in his ability to help in an emergency. In addition to first aid for specific injuries or illnesses, Jacob also demonstrated knowing how to direct others in an emergency and when to call for a doctor.

Transcript 4

Line	Speaker	Speech
1	Jacob:	I helped my brother.
2	Researcher:	Yeah? What did you do for your brother?
3	Jacob:	He was playing with a pile of dirt and he fell.
4	Researcher:	Oh, what did you do for him?
5	Jacob:	First I washed [until] where the wound was clean and I put some pressure.
6	Researcher:	Pressure, to stop the bleeding?
7	Jacob:	Yes and then I tied a piece of cloth.
		…
8	Researcher:	Yeah, so you feel like that can help more than just the school? How do you think that can help the community?
9	Jacob:	If somebody has fainted and people are just gathered around, I would tell them to move a space and then I put someone to call a doctor and then I know how to help them.

5.2 Diseases

According to the World Health Organization (WHO, 2008), one of the most effective ways to prevent the spread of diseases is through hand-washing. If a person washes their hands often and well, they can be 25% less likely to contract a respiratory illness and half as likely to contract a stomach bug, which represent the two biggest killers of young children (WHO, 2008; The Global Public-Private Partnership for Handwashing with Soap, 2008). Because hand-washing is an important part of spreading diseases and so many students specifically referred to an interest in learning about hand-washing, Mme. Atieno and I decided to make it a full unit. For research purposes as well, any applications where students mentioned when or how to wash hands is included in the section above. In this section on diseases, I include any other applications students' discussed that related to understanding, treating, or preventing the spread of diseases. In the unit on diseases, students were provided opportunities to learn about diseases by (1) examining the F-diagram and using it to determine ways to block common diseases from spreading; (2) playing a game on blocking imaginary disease transmission through the class; (3) categorizing similar diseases to understand commonalities in transmission, symptoms, and treatment; (4) doing research in groups on a disease of interest and performing mini dramas on when to see a doctor; (5) taking a fieldtrip to the local clinic and talking to nurses about disease symptoms, testing, and treatments; (6) acting out a play on how the immune system functions and what happens when it is attacked by HIV (Peace Corps, 2001); and (7) having a class discussion on HIV/AIDS questions the students had.

For reference on the first activity and relevant applications, Figure 18 shows a diagram the students were taught for major transmission routes of common fecal-oral diseases. Blocking any of the transmission paths shown on this diagram will likely minimize the spread of common diseases (though this does not include sexually-transmitted diseases like HIV/AIDS or vector-transmitted diseases like malaria).

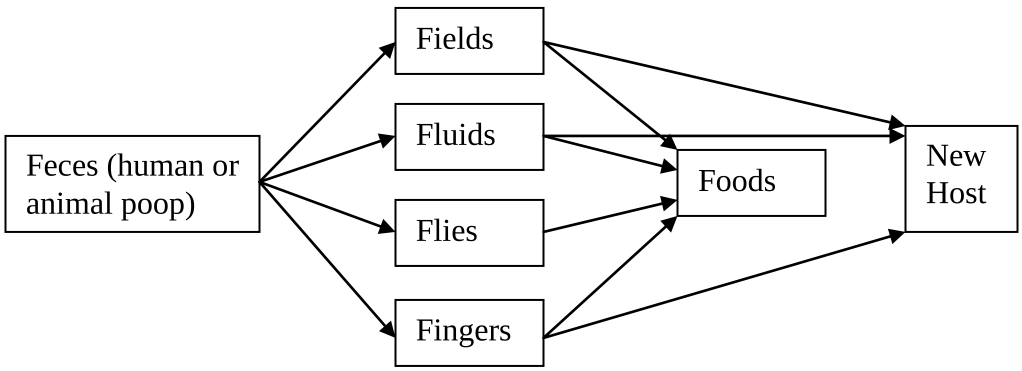


Figure 18. Reproduction of F-diagram for major transmission routes of fecal-oral diseases. Adapted from Winblad U & Dudley E. (1997).

To prevent the spread of diseases, other than teaching hand-washing, most students discussed actions they had taken to prevent the spread of diseases at home and at school. In the health club, students had the opportunity to map how common respiratory illnesses spread and came up with solutions for how diseases can be prevented at multiple levels along the map (See F-diagram in Figure 18 above). For example, a fly landing on an uncovered latrine could carry a disease from the latrine into an uncovered pot of food. Two areas in this example where a student could make a change to prevent the spread of diseases are (1) by cleaning or covering the latrine or (2) by covering the food so that flies cannot land in it. In some instances, students expressed the need for health changes that they themselves felt comfortable applying such as cleaning latrines or covering food (an example of this is provided in Case 2 at the end of this section). In another instance however, one student suggested that there is a lack of latrines by the lake, but did not yet feel able to make such a change. He felt that building more latrines by the lake would encourage people to use them, rather than the lake for disposing of human feces. In addition to these changes, some students did teach methods for preventing disease to their families. Table 21 shows the ways in which students applied or intended to apply what they had learned about disease-prevention.

In their pre-surveys, all students made a connection between health and preventing the spread of disease in open-ended questions on how to stay healthy in their pre-surveys (see Table 22). The most commonly discussed connection was the idea that preventing exposure to mosquitos would minimize the spread of malaria. Students talked about needing to clean their home and school compounds to prevent bushy areas or stagnant water where mosquitos breed. They also discussed the need to sleep under a mosquito net which most students reported consistently doing. On the other hand, students showed very little connection

Table 21

List of the Ways that Students Applied or Intended to Apply Learning about Disease-Prevention

Disease-Prevention Concepts	
Prevent spread of disease…	Clean the environment/rooms
	Clean/cover/build latrines
	Cover food/windows
	Vaccinate
Teach disease-prevention (e.g., cover mouth when coughing)…	To family
	To classmates/teachers
	To community

between improving health and preventing diseases that spread from person to person. Even in their background knowledge on HIV/AIDS, students mainly discussed contracting the virus from sharing a razor rather than from person to person directly through intravenous fluids. Over half of the students in the study reported a prior interest in learning about diseases (see Table 23). Students were highly engaged in class discussions and many did independent research on specific diseases they were interested in learning about. Table 22 compares whether students indicated a connection between health and preventing the spread of diseases with whether students applied or intended to apply what they had learned about diseases. Table 23 compares students' pre-interest in learning about diseases with their application.

Table 22

Pre-Connection Between Preventing the Spread of Disease and Health Compared to Application, Intended Application, and No Application

Diseases	Students indicating application	Students indicating intention to apply	Students not indicating application or intention	**Total**
Students reporting prior connection between disease-prevention and health	7	10	3	**20**
Students not reporting prior connection between disease-prevention and health	0	0	0	**0**
Total	**7**	**10**	**3**	**20**

Table 23

Pre-Interest in Preventing the Spread of Disease Compared to Application, Intended Application, and No Application

Diseases	Students indicating application	Students indicating intention to apply	Students not indicating application or intention	**Total**
Students reporting prior interest in learning about diseases	3	6	3	**12**
Students not reporting prior interest in learning about diseases	4	4	0	**8**
Total	**7**	**10**	**3**	**20**

Case four: providing, cleaning, and covering latrines at school and in the community. Some of the most common diseases in Namerokamano are spread through fecal matter (see Figure 18 for methods of transmission). In the health club, students used models of how common disease-causing germs (leading to things like respiratory illness and diarrhea) typically spread to come up with solutions that would block those pathways. For example, if a fly lands in contaminated feces then lands in food, the food will likely cause someone who eats to become sick. Solutions that students came up with included preventing flies from getting into contaminated human feces by cleaning and covering latrines, covering food, and washing food. These practices would provide several ways to minimize the spread of disease-causing germs. Transcript 5 below shows that students considered making changes in their home and school along multiple pathways which would provide many ways to minimize the spread of diseases.

Transcript 5

Line	Speaker	Speech
1	Katherine:	I can help clean the latrine to prevent diseases.
2	Researcher:	That will help because a lot of diseases are spread by feces of humans and animals.
3	Katherine:	And the house fly.
4	Researcher:	Yeah, the house fly also. That can really help. What about you? How can what you learned help you to be healthy?
5	Beth:	I can keep the latrines covered.
6	Researcher:	Ah, keeping those covered. That can help a lot.
7	Doreen:	I can help I and my family to be healthy by drinking treated water.
8	Researcher:	That's a good one. You can prevent a lot of diseases.
9	Apiyo:	Here in school, we can help by teaching other pupils that they should wash their hands when they are from visiting the latrine or playing.

5.4 Balanced Diet

Students did not initially show interest in learning about balanced diets from their pre-surveys. The interest developed during an activity in which students categorized diseases. In learning that several diseases are caused by a lack of nutrients (e.g., anemia from lack of iron), students wanted to learn more about how to ensure they received proper nutrients to prevent such diseases. Because of these discussions and Mme. Atieno's observations that many of her students in early elementary grades were malnourished, she and I designed a short one-meeting period unit on maintaining a balanced diet using local foods. In this unit, students were given the opportunity to learn about balanced diets by (1) sorting real, locally available foods into categories based on similar nutrients and functions in the body; (2) planning a day of balanced meals by selecting at least one food from each group; (3) discussing health implications for maintaining a balanced diet; and (4) providing a balanced meal to the school and teaching younger students about balanced diets on Health Day. Students reported more intentions to apply their learning about maintaining a balanced diet than actually applying their learning. Some students did, however, report teaching their family members about balanced diets especially their mothers. Table 24 shows the ways in which students applied or intended to apply their learning. Table 25 and Table 26 compare students' prior-connections with maintaining a balanced diet and health and their prior interest in learning about balanced diets with their applications, respectively.

Table 24

List of the Ways That Students Applied or Intended to Apply Learning about Balanced Diet

Balanced Diet Concepts	
Maintain a balanced diet…	Buy food from each food group Eat a balanced diet Serve balanced meals Start a school vegetable garden
Teach balanced diet (e.g., affordable proteins)…	To family To classmates/teachers To community

Table 25

Pre-Connection Between Maintaining a Balanced Diet and Health Compared to Application, Intended Application, and No Application

Balanced Diet	Students indicating application	Students indicating intention to apply	Students not indicating application or intention	**Total**
Students reporting prior connection between balanced diet and health	0	0	0	**0**
Students not reporting prior connection between balanced diet and health	4	8	8	**20**
Total	**4**	**8**	**8**	**20**

Table 26

Pre-Interest in Learning about Maintaining a Balanced Diet Compared to Application, Intended Application, and No Application

Balanced Diet	Students indicating application	Students indicating intention to apply	Students not indicating application or intention	**Total**
Students reporting prior interest in learning about balanced diet	0	0	0	**0**
Students not reporting prior interest in learning about balanced diet	4	8	8	**20**
Total	**4**	**8**	**8**	**20**

Case five: teaching mother that a balanced diet can be affordable. While balanced diet was a short unit where most students did not report applying their learning outside the classroom, it is included in this analysis since students applied this knowledge in impactful ways. Students who did teach their families, especially their mothers, about balanced diets reported specifically showing their families that a balanced diet could be affordable and use locally available foods. In fact, this trend of affordable balanced diets came up in almost every focus group. Students taught their families that local green vegetables that grow in the wild during the rainy season are equally valuable to more expensive imported vegetables. The same realization was made of proteins. In students' textbooks, proteins are shown as coming from fish, chicken, cows, or goats. All of these are perceived by the students to be too expensive, making a balanced diet nearly impossible. In the health club, students realized that beans, lentils, and eggs are also sources of protein and these are much more affordable. It is this connection bridging local, affordable foods with an understanding of a balanced diet that students explained to their families.

Transcript 6

Line	Speaker	Speech
1	Doreen:	It is not a must that you must eat some expensive foods to make a balanced diet.
2	Researcher:	No, it's true. You don't need to pay a lot of money to have that balanced diet.
3	Doreen:	You can even eat some vegetables like mboga [local green vegetables] to have a balanced diet.

Transcript 7

Line	Speaker	Speech
1	Researcher:	What did you teach your mother?
2	Paul:	She always complains about having a balanced diet. So I taught her that it is not a must that we have meat every day. We can also use omena [small fish] or eggs and eat it with apoth, susa [local green leafy vegetables] to have a balanced diet. …
3	Paul:	I liked learning about balanced diet because it has taught me, through this health club, it has helped me to improve on having a balanced diet. We are talking about how to take a balanced diet which is not even depending on whether you have lot of money or not.

5.6 Summary

At home, the behavior changes students initiated varied. Younger students tended to take on more responsibilities teaching siblings while older students made changes to how water was stored and what food was purchased. When I had dinner at Anna's, one of the health club members' homes, I observed her two younger sisters reminding each other to use Anna's method for hand washing.

Some health club members were limited in their ability to make changes in their homes that parents or guardians would typically make, but one older student was extremely successful. Paul offered to buy food for his family and worked with his mother to spend the same amount of money on more balanced meals. He said that he did not need to change much, just keep better track of purchases to ensure that each meal had food from each of the food groups.

One struggle that students had in making changes was limited participation in financial decisions. They were able to successfully apply what they had learned in health club so long as they had the necessary supplies. For example, one health club member made a rehydration drink for his younger sibling when he was sick and found that he had salt, sugar, and water in the house and all he had to do was mix them together. In observing hand-washing at the students' homes, they often knew the value in using soap, but did not have it available. This lack of resources made applying their knowledge more difficult.

At school, the challenges and supports for making changes differed from those at home. Students in the health club were encouraged by their principal to take on responsibilities for school health and sanitation. When superintendents, politicians, teachers, parents, and school board members met for an Open House event, the principal asked the health club to carry water from the neighboring high school's pump, treat water for drinking, and run a hand-washing station to help guests wash their hands before eating lunch. The health club members even taught their principal how to thoroughly wash his hands and scrub between his fingers while he smiled and chuckled.

The health club members were perceived as leaders in sanitation monitoring at their school. Every Friday, all of the students cleaned the campus. In each grade, one elected student was in charge of directing classmates to pick up trash, sweep, and mop the classroom floor. The health club, without prompting from teachers or their principal, assumed this same leadership role for Friday cleaning of the latrines. They organized students to sweep and wash the latrine walls and floor.

At one point, the girls' latrine collapsed because it had become too full and was extremely unsafe. When the principal began plans for a new latrine, the health club members asked that plans include a place for hand washing and a stall where girls could clean themselves. With limited access to sanitary napkins and adequate sanitation at school, many girls stay home when menstruating. The health club teacher helped design this washing area which will likely allow girls to remain in school during these times.

After the health club lesson on hand-washing chemistry, students were asked to teach someone else the hand-washing method they had developed. For the assignment, students mainly taught their classmates and siblings. Most students reported teaching more than the one student they were asked to instruct and continued to teach their peers other health topics. On one occasion, a student asked me to assist with his lesson on HIV and AIDS. He said that he had been teaching his class the previous topics we learned in health club, but could not remember all of the details for how the HIV virus affects immune systems. I went into his classroom and found that he had drawn most of the diagrams from our health club on the board. I just stepped in to help with an ongoing discussion and answer a few questions. Even the health club teacher extended lessons from the health club to her other classes. She taught the hand-washing lesson to her kindergarteners and even another teacher so he could help assist with the activity.

Chapter 6: Findings on Factors that Influenced Students' Likelihood of Applying their Science Knowledge toward Improving Health

This chapter answers research question 3) What factors seemed to influence whether students applied or intended to apply what they learned in the health club? Section 6.1 describes internal or student-oriented factors, 6.2 describes external (environmental, political, financial) factors, 6.3 describes relational factors between the health club students and their community, 6.4 describes factors specific to the health club, and 6.5 describes cultural factors and bridging strategies that influenced students' application or intended application of their learning. Table 27 introduces the factors identified from focus group interviews and ethnographic observations that influenced students' application of their learning. The first three factors (internal, external, and relational) are similar to those suggested in the social ecology model of health determinants (Panter-Brick et al., 2006), while the second two factors (science education and cultural factors) support suggestions for connecting students and science from education literature (Aikenhead, Calabrese-Barton, & Chinn, 2006; Cooper, Chavira, & Mena, 2011; Le Grange, 2007).

Table 27

Factors Influencing Students' Application or Intended Application of Learning

Internal/Individual	External	Relational	Science Education	Cultural
Age	Financial	Social Networks	Science and Engineering Practices	Cultural Broker
Self-Efficacy	Time	Organizational Support		Bridging Strategies

6.1 Internal (Individual Student) Factors

This section considers internal factors that may influence students' application or intended application of learning in their home, school, and community. Gender and age are specifically explored in this study and discussed below, though there was some evidence to suggest there may be other internal factors that influence students' application of their learning.

Gender. In Namerokamano, like many rural areas in Sub-Saharan Africa, girls and women have many opportunities to integrate science and engineering practices to improve health in their community. It is women and girls who are typically responsible for cooking, fetching water, cleaning the house, and caring for younger siblings. These roles seemed to allow the students in this study to apply what they had learned about balanced diets, water quality, disease prevention, and first aid at home. Boys also have similar responsibilities around the house and were able to apply what they had learned. In addition, boys seemed to take on leadership roles in the home and community and many were able to teach older siblings and parents. There was little difference in the number of boys and girls were in the high application category (6 males and 4 females). In fact by percentages, an equal proportion of boys and girls (50% of boys and 50% of girls) demonstrated a high level of applying what they had learned. Additionally, the girls in this study were less talkative during interviews than the boys and this gender difference in participation was also observed in classroom participation where girls seem less likely to raise their hands and answer questions in class (this observed difference was also confirmed by Mme. Atieno). The boys may then have been more likely to talk about the ways they had applied their knowledge than the girls. That said, students of both genders reported being able to apply science and engineering practices outside the classroom and teach others what they had learned, so in this study, gender did not seem to influence whether students applied their learning. Table 28 shows the number of boys and girls who were ranked high, medium, and low with regards to their frequency of applying what they had learned.

Table 28

Gender Compared to Across-Topic Application

Across topics	Students indicating high application	Students indicating medium application	Students indicating low application	**Total**
Male	6	4	2	**12**
Female	4	3	1	**8**
Total	**10**	**7**	**3**	**20**

Age. Unlike gender, a students' age played a large role in their likelihood of applying what they learned in the health club outside of the classroom. Of the ten students who frequently applied what they learned, 9 were 13-14 year olds and only 1 was 10-12. In fact, all 10 of the 13-14 year olds in this study were able to apply what they had learned in some way. Older primary students still tend to live at home when going to school in Namerokamano, though they have more responsibilities in their home, school, and community than do younger primary students. The older students may also have been at an advantage by speaking and understanding English (the primary language of instruction in school and the health club) as compared to the younger students in the study. Another consideration is that while older students were more likely to apply what they had learned during the six months of the program, many of the younger students still discussed intentions to apply what they had learned in the future. More of the older students, however, applied what they had learned during the course of this study. Table 29 shows the number of younger (ages 10-12) and older (ages 13-14) students who were ranked high, medium, and low with regards to their frequency of applying what they had learned.

Even though students of similar ages tend to be in the same grade (in the US these are highly correlated), there is some slight variance between age and grade in Kenyan Schools and for the participants in this study. Because of these differences, I also compared students' application of their learning with their grade level. Table 30 shows the application levels for students in lower (grades 5-6) and higher (grades 7-8). The slight differences in the two tables below show that age may be a more crucial factor than grade level in a student's likelihood of applying what they learned outside the classroom.

Table 29

Age Compared to Across-Topic Application

Across-topics	Students indicating high application	Students indicating medium application	Students indicating low application	**Total**
Ages 10-12	1	6	3	**10**
Ages 13-14	9	1	0	**10**
Total	**10**	**7**	**3**	**20**

Table 30

Grade Compared to Across-Topic Application

Across-topics	Students indicating high application	Students indicating medium application	Students indicating low application	**Total**
Grades 5-6	2	4	3	**9**
Grades 7-8	8	3	0	**11**
Total	**10**	**7**	**3**	**20**

Other internal factors. Other internal factors that may have influenced students likelihood of applying what they learned are self-efficacy regarding their ability to do or teach science, cultural identity and sense of involvement within their home and community, and cultural-efficacy in light of a colonial past when communities in Kenya, like Namerokamano, were historically restricted from mobilizing and making changes. From informal conversations with the students and Mme. Atieno, it became apparent that these internal factors may have impacted whether or not a student felt like it was possible to make changes regardless of their external support to do so and are thus internalized. For example a student whose parents have passed away and who now lived with other relatives might feel uncomfortable applying learning in the new home because of internal feelings about their position in the household. This may have been the case for one or two of the students in the health club, but the analysis required to understand such complex internalized factors is beyond the scope of this study. While these other internal factors are not explored further here, there is some evidence (from interviews and informal discussions) that these played a role in how students positioned themselves within their community and consequently whether they could apply what they had learned.

6.2 External (Financial, Political, Environmental) Factors

External factors seemed to influence whether or not students were able to apply what they learned even if they had intentions to do so. In some cases, a student tried to apply his or her learning, but was limited by the availability of economic resources or time, leaving their attempt an intention. On the other hand, availability of external resources provided by parents or time provided by school administrators supported students and enabled them to apply their learning.

Economic. Economic factors influenced students' ability to obtain materials for their applications. For example, even though most students taught others how to wash their hands using evidence they had gathered on how soap bonds with oil and water, many students did not have access to soap in their homes or even at school. Soap costs money and it is difficult to argue whether having limited money should be spent on soap to prevent disease or to treat disease later. Students might not have had the power or the financial means to make that decision. When there is even less money available, soap is not an option. Even in the school, the little soap that was available was used for washing dishes from the teachers' lunches. Students did not have access to soap, limiting their ability to apply ideas like providing soap and water for hand-washing stations near the school latrines.

Time and Support. External factors such as support from community leaders and school administrators and time provided in school helped encourage students to apply what they had learned. This was made apparent when the school principal asked the health club to participate in Education Day. On Education Day, the school board and district officials came to the school for a meeting and event. The health club was supported by the principal and acknowledged for their contributions to the school. They were asked to treat drinking water for the day, set up hand-washing stations, and even instruct the school and local government officials on proper hand-washing techniques. This gave the students the confidence that they could teach anyone. This confidence is apparent in Transcript 8 below where students in one of the focus group interviews talked about who they could teach to wash their hands. Time was provided by the school principal to teach other pupils and teachers at school events. These external factors enabled Apiyo, Beth, and Doreen to have such opportunities to teach many people at their school and they were confident in their ability to do so in the future.

Transcript 8

Line	Speaker	Speech
1	Apiyo:	Here in school, we can help by teaching other pupils that they should wash their hands when they are from visiting the latrine or playing.
2	Researcher:	Yeah, so you can even teach the other pupils that one?
3	Apiyo:	Even teachers [laughing]
4	Researcher:	Yeah, they might forget. Do you feel comfortable teaching the teachers those things?
5	Apiyo:	Yes, I can teach them.
6	Researcher:	And what about the other pupils, do you feel comfortable?
7	Apiyo:	I can also teach them.
8	Doreen:	And others need.
9	Researcher:	Yeah, who else do you think we should teach? Who else do you think you can teach?
10	Beth:	Our parents
11	Researcher:	Your parents? Good.
12	Doreen:	And others.
13	Researcher:	Who, like [one of the village elders]?
14	Doreen:	Yeah [laughing]
15	Researcher:	Will they listen to you if you teach them those things?
16	Doreen and Apyio	Yes.

6.3 Relational Factors between Target Group and Community

The relationship between the health club and the community also played a role in whether practices and knowledge could move between the two. While the health club students lived in the community, they also must have had relationships that allowed for interactions to occur for them to apply what they learned outside of the health club.

Social Networks. Social networks or connections between the health club and the larger community were important factors influencing students’ application of learning in the larger community. Before this study, I conducted a pre-study with a secondary school for girls in Namerokamano (see Section 3.6 for details). Namerokamano Secondary School is a boarding school where students live and study. They rarely leave the campus except for school holidays and many of the students are not from the local community, but come from other nearby towns. In addition, students have a strict schedule with little time for sharing what they learn in the health club let alone meeting with the health club regularly. Regardless of the students' intentions to learn or to improve their community, their high school remains detached from the community in many ways. During the pilot study, the students learned science and engineering practices and strategies that may someday help them apply what they learned toward improving their communities; however, opportunities for students to do this during the pilot study were limited.

Organizational Support. The relationship between the Namerokamano Primary School and the community, on the other hand, was much stronger. Students had strong pre-existing networks with the larger community and the school provided organizational support to enhance those networks. Primary school students attended school from sunrise to around noon then returned home or went into town. Except for the pre-schoolers and kindergarteners who stayed with their families, the students returned for more classes. After an hour, they had sports, singing, and clubs in the afternoon and one more class or studying before leaving around 4 pm. After school, most primary students either did chores at home or ran errands for their families. This took students into town, to the water pumps, to the mill, or to the lake with laundry or animals. The students then had dinner with their families and studied when the sun went down. Primary students were an integral part of their community and had many opportunities to apply what they learned in the health club beyond their school. This relationship between primary students and their larger community was a foundational factor that influenced the likelihood of whether they, as the target group, could improve the health of the community.

6.4 Science Education (Health Club) Factors and Learning Science and Engineering Practices

In primary school, students are exposed to biology, chemistry, physics, and environmental science concepts that relate to health; however, often this science seems disconnected from or impractical to their everyday lives. For example, images in textbooks showing hand-washing typically display hands being washed in running water from a tap while Namerokamano does not have plumbing at the household level. In their pre-surveys, students brought up questions about potential applications of health and science solutions to community needs. To mitigate the disconnect students experienced with school science and their lives and to respond to the questions they had about health and science in their community, the health club was designed for students to experience transferrable practices of science. Mme. Atieno and I designed opportunities to learn science and engineering practices with the goal of helping students connect prior knowledge and interests as well as make connections between school science and their community. In addition to a focus on the practices of science, opportunities for teaching others and applying learning outside of the health club were built into the curriculum. For example, students were encouraged to teach someone else the method they designed for hand-washing. Students were also encouraged to collect evidence from home to use in the health club like home water tests. Refer to Table 7 in Chapter 4 for an overview of activities, place or community-based prior knowledge students accessed, and science and engineering practices that Mme. Atieno and I incorporated into activities.

Analyzing/interpreting data and constructing explanations were two of the science and engineering practices students found to be most important for applying their learning beyond the health club. Students recalled the evidence they collected themselves and used that evidence to convince themselves and others. In Transcript 9, Doreen, Katherine, Beth, and Apiyo reflected on the experiments they did to compare bacteria in water. These students recalled the conclusions they made from their own studies.

Transcript 9

Line	Speaker	Speech
1	Doreen:	Lake water has more [bacteria] than others. [The other girls nod]
2	Researcher:	That's what you learned too, about the lake water?
3	Katherine:	I learned that the rain water is good when you boil it.
4	Researcher:	So, boiling it can kill of some of those bacteria?
5	Beth:	Ground water can have less
6	Researcher:	Groundwater? Yeah.
7	Apiyo:	I can believe that it is better to treat.
8	Researcher:	It is smart to believe.
9	Doreen:	I learned that if you want to know that water is good for drinking, you can test it.

Students relied on such evidence-based explanations to teach others and motivate changes in their homes, school, and community. Paul described the best ways he had found to teach others what he had learned when he said, "I think teaching and bring the experiments for them to see on how it is. For example, I cannot tell them that drinking another water is good and it is not just good without explaining" (Paul, focus group interview). In teaching others, students relied on not only the evidence they had collected but multiple practices of science even teaching others through these practices.

6.5 Cultural Factors and Bridging Strategies

Cultural factors played a substantial role in students' likelihood of applying their science knowledge toward improving community health. As discussed earlier, students' cultural worlds are often divided from the world of science by what Aikenhead (1999) refers to as fortified borders. Jegede and Aikenhead (1999) suggested that because of these borders, students need support in moving between the two cultures. Aikenhead, Calabrese-Barton, and Chinn (2006) later proposed that because of this need, learning science can be perceived as culture acquisition. Furthermore, Cooper, Chavira, and Mena (2011) suggested that teachers can help students negotiate this process of cultural acquisition by acting as cultural brokers. In this role, teachers can guide students between their own community or place toward science and the culture of science.

The findings in this section support the theories recalled above by showing how Mme. Atieno acted as a cultural broker to connect students' cultures with science. Furthermore, these findings illuminate bridging strategies the students recognized as paramount to crossing barriers in order to both connect their community to science and apply science to their community. In this sense, these findings show that bridges, or explicit connections made by the teacher, helped cross cultural borders and the teacher used bridging strategies, specific strategies to make these bridges available to students. Bridges and bridging strategies then become supportive cultural factors that supported students' abilities to apply their learning outside of the health club.

For students, cultural factors can act as bridges, like the connection between the everyday cultural practice of rinsing hands before eating and the F-diagram model of germ theory for common respiratory and stomach illnesses (see Figure 18); however, such cultural factors can also act as gatekeepers, like the assumption that the cultural practice of pouring water differs from running tap water shown in books. In this study, Mme. Atieno recognized and addressed cultural factors as they emerged throughout the course of the health club. She and the activities provided bridges that helped students connect different cultural factors to what they were learning.

Bridges were identified from fieldnotes and interview data by creating a timeline with interview codes from earlier questions to explore students' applied learning. These codes were organized to trace backwards and forwards in time from connections students described making between science and place. For example, Doreen explained learning to connect local practices with what she learned about maintaining a balanced diet when she said, "You can even eat some vegetables like mboga to have a balanced diet" (Doreen, focus group interview) as she described how she applied her learning about maintaining a balanced diet. This example shows a bridging strategy from local science to school science. Locally, mboga [Kiswahili word for green leafy vegetables including spinach, kale, pumpkin leaves, and wild greens] are thought to be affordable and readily available in local markets or growing wild. On the other hand, because textbooks often reflect more urban areas in Kenya or other countries, they typically show other vegetables besides the ones the students have locally so students do not see the commonalities between the two. In the health club, students grouped local foods and categorized them into food groups that would help them have a balanced diet. This activity helped connect local foods to students' school science knowledge about food groups. Table 31 lists bridges that students used throughout the health club, strategies used, and the borders the bridges crossed between.

Table 31

Bridges and Strategies Used in the Health Club to Develop Connections Between Science and Place

Bridge		Strategy	Example from health club
From	To		
Place	Place	Asking students guided questions to connect their individual interests in solving local problems to existing community behaviors	Discussion on first day about health in community. Students were guided in a discussion and their responses were listed on the board
Place	Science	Categorizing locally observed phenomena and comparing the groups based on local implications and scientific theory	Categorizing familiar local diseases based on symptoms, how they spread, and potential treatments at the local clinic
		Categorizing locally available resources and comparing the groups passed on local implications and scientific theory	Food sorting activity. Students sort locally bought foods into categories based on how they are used by the body then discussed connections to deficiency diseases
		Using locally-relevant metaphors for explaining abstract concepts	Playing an elephant/lion immune system game
		Asking students guided questions to identify their individual interests in solving local problems and connecting these interests to place-based and scientific resources	Identifying familiar situations where first aid would be helpful and doing research using science publications and local resources (e.g., nurses)
		Using engineering processes to solve local problems	Rainwater system planning to solve the problem of limited access to water at school
		Using scientific models to help students answer questions about locally relevant health concerns	HIV/AIDS questions and connections to immune system and HIV virus models
		Observing local phenomena and developing scientific explanations to make sense of observations	Watershed walk and mapping to show water movement and possible sources of contamination

Bridge	Strategy	Example from health club

From	To		
Science	Science	Using model-based inquiry to construct scientific arguments and explain phenomena	Chemistry (oil, water, soap) modeling activity and using evidence to create hand-washing method
		Collecting and interpreting data from local source to construct scientific arguments	Testing lake water for bacteria and using evidence to predict connections between water and health
		Constructing design-based solutions to explore science concepts	Designing water filters to explore turbidity and engineering practices
Science	Place	Apply science learning by teaching others	Encouraged to teach hand-washing methods to others
		Planning school-wide events where students practice science that meets the needs of the school	De-worming/ education day planning. Students helped plan and run a school-wide event to treat worms and teach about balanced diet
		Preparing questions and asking questions of local science experts	Clinic fieldtrip and questions for nurses on disease prevention and treatment
		Using scientific properties of local resources to plan everyday practices	Meal planning activity based on nutritional content of locally available foods
		Applying science in unplanned local situations as they arise	Teachable moment on stopping nose bleeding
		Using science to design something for local use	Designing and making a health text book for classroom and clinic use
		Doing experiments as a class and then providing materials for students to conduct similar experiments at home	Testing water in the home and using results to make decisions on storage and treatment methods

Over the course of the health club, students were able to connect community and school science using multiple bridges. These bridges served to tie place and community into the science students were learning in school. Students also used bridges to connect community science to school science and engineering practices. Bridging strategies for helping students make such connections were particularly important for overcoming economic barriers and limited access to materials. For example, Nasir described his change from thinking that good hand-washing must use resources, which were difficult for him to obtain, to designing new techniques with what was available. “For me, I used to think that I must use a towel, but now I know I can nini [shaking hands]” (Nasir, focus group interview). Here, Nasir was able to use the activity in the health club applying evidence from experimenting with hand-washing to design his own method for hand-washing and bridge a barrier regarding access to a clean towel.

While literature supports the notion of border-crossing between place and school science (Aikenhead, Calabrese-Barton, & Chinn, 2006), additionally important were intermediary strategies of connecting science and engineering practices to evidence. Recall that students had opportunities to gather evidence and use evidence to support claims in the health club. Students frequently brought up the need to connect science and engineering practices with evidence in their focus group interviews. For example, Jeff discussed using the evidence from his water testing to teach his brother why it is important to treat water for drinking and cooking. Connecting science and engineering practices to evidence and connecting evidence to applications allowed students to use the evidence to convince others and better share what they had learned outside the classroom. Paul described the need to use evidence in teaching others when he explained, “I think teaching and bring the experiments [showing the water test results] for them to see on how it is [is important]. For example, I cannot tell them that drinking another water is good and it is not just good without explaining" (Paul, focus group interview). In this case, the bridging strategy connecting science and engineering practices for testing bacteria in water with explanations based on evidence allowed Paul to better teach others about whether certain water sources were safe to drink.

Figure 19. A health club student and her younger sister comparing the ground water and rainwater used by their family. Another family member is taking the photo as the student checked out all equipment, including the camera, to do her home experiment.

In another example, Anna collected evidence on the quality of water at her home by borrowing equipment to do experiments there. Figure 19 above shows her doing water testing with her younger sister who helped her with the experiments.

Chapter 7: Discussion

7.1 Summary of Findings

Students were provided opportunities to learn the practices of science and connect those practices to their local community. As part of the connections students made, they applied learning across health topics they identified as relevant: hand-washing, disease-prevention, first aid, balanced diet, and water. Their applications were influenced by internal, external, and relational factors with the community; science education factors; and cultural factors. Some factors, which may have been barriers for students to apply their learning were turned into supports via bridging strategies used by the students and teacher. These bridges were critical in bringing students' place into the classroom and enabling students to apply their learning toward place.

The model resulting from the identified factors informed existing models for sociocultural considerations in community-based health interventions. The community-engagement applied practices of science (CAPS) model serves to conceptualize findings in this study and proposes an integrated method for using community-engagement education as a stimuli for students to become cultural brokers and improve community health. Taken with the focus on teaching practices of science and encouraging students to apply their learning, this research suggests that bridging strategies can be used to connect science with place in meaningful ways that serve both students and their local communities. In Section 8.1, each research question is addressed and major findings are summarized.

In what ways were learning opportunities for using the practices of science to improve community health made accessible to students through the health club? Learning opportunities for using the practices of science to improve community health were made accessible to students through planned science activities and encouragement to apply the practices and findings outside of the classroom. Planned science activities used science and engineering practices from chemistry, biology, physics, and engineering while focusing on health connections and implications. Students were encouraged to teach others what they had learned, make changes in their homes, participate in improving school health and sanitation, and communicate science research findings to the community. The health club curriculum, including the activities and encouragement to apply learning, was grounded in students' own health interests and awareness of health issues in their community. Students were also encouraged to explore and incorporate emerging interests into the health club to help the program evolve with the changing needs of the students and their community.

In what ways did students apply science and engineering practices learned from the health club in their homes, school, and community? Students applied their learning across multiple health topics including hand-washing, disease-prevention, first aid, balanced diet, and water. Hand-washing was the most frequently applied health topic. Students most often applied what they learned about hand-washing by teaching others, especially family members and classmates, how to wash their hands. In contrast to hand-washing where most students applied what they had learned by teaching others, students most commonly discussed applications of learning how diseases spread to actually preventing their spread at home and at school. Students cleaned the school compound, cleaned and covered latrines, and covered food and windows. More students had intentions of applying what they learned about disease prevention, but had not acted on those intentions. Students both taught and applied first aid to others, but also had more intentions than actions, like with disease-prevention. Students taught balanced diet to others, especially their families. Many students reported specifically teaching their mothers that a balanced diet could be affordable or offering alternative, more affordable options for proteins in their explanations. Students both applied their knowledge of water by actively changing the way water is stored and treated as well as by teaching others. They most often applied their knowledge about water by treating the water for drinking and cooking in their homes. There was also substantial discussion in focus groups about changes students intended to make regarding water. The ways in which students applied their learning were many and varied, and most frequently, changes were made at the home level.

What factors seemed to influence whether students applied or intended to apply what they learned in the health club? Students' application or intended application of learning toward health improvements was influenced by a combination of internal (student-oriented), external (environmental, political, financial), and relational factors with the community, science education (health club intervention) factors, and cultural (and culture-science interactional) factors. The most apparent internal factor was age with more students who were 13-14 year old applying learning than the 11-12 year olds in the study. That their age was a factor indicated that older primary students held responsibilities in their homes, school, and community and were able to apply their learning in these contexts. Since high-school students and adult males are often distant from community practices and women are incredibly busy in the home, primary students offered an opportunity to leverage as community leaders because of supportive relational factors between these students and their community. External factors served as both barriers (e.g., limited access to materials like soap and water) and as support (e.g., active and supportive school principal who encouraged the health clubs involvement in campus sanitation improvements). Science education factors served to provide opportunities for learning transferrable science and engineering practices and obtaining evidence as part of these practices. Though students were encouraged to apply their learning outside of the classroom, the evidence and interpretations they made from science research enabled them to do so. Cultural factors, which may have been barriers, were in fact turned into supports via bridging strategies used by the students and teacher. Bridges allowed students to connect place and science in ways that helped them navigate both worlds. These bridges were critical components in both bringing students' community and place into the classroom and enabling students to apply their learning toward their community and place.

7.2 Implications for Health: A Revised Model for Fostering Student-Initiated Health Improvements

As discussed in the literature review, models are commonly used in fields of public health and health education to describe determinants of disease and health in populations. They assume specific perspectives, help communicate concepts, provide transparency, facilitate discussion and collaboration, lead to hypothesis formulation, identify potential points of intervention, and define expected outcomes of interventions (Fielding, Teutsch, & Breslow, 2010; Grizzell, 2009). This research builds off of integrated (Fishbein, 2000; Montano & Kasprzyk, 2008), sociocultural (Panter-Brick et al., 2006), multiple determinants (Kindig & Stoddart, 2003), and community-engagement (Minkler, Wallerstein, & Wilson,

2008) focused models which perceive health determinants as connected to and driven by communities. See Section 2.3 in the literature review and Figures 4, 5, 6 for more detail on these models.

As an implication of the findings in this study, I propose a revised model that embeds a data-driven intervention strategy into well-established health models with the goal of identifying potential methods for intervention and communicating concepts that intersect health and science education. It is important to remember that community health is complex and involves many different, yet intersecting factors. The proposed model is limited in scope by its goals and target group; nevertheless, it will facilitate discussion and collaboration in finding effective ways to use science education toward improving health at a community level.

Proposed Model of Fostering Student-Initiated Health Improvements through Science Education: Community-Engagement Applied Practices of Science (CAPS). Integrating science education as an intervention strategy in community-engagement health models provides useful connections between science and the community. Figure 19 depicts my proposed model that uses science education and applied practices of science to foster student-initiated community health improvements.

Notice that there are three key novel changes I propose. These areas are each marked by a star and numbered on Figure 19 below. These modifications stem from my work in Namerokamano and include (1) a community-engagement education context that specifically addresses cultural factors, (2) additional transitions from intentions to action, and (3) maintenance for sustained, scalable, and adaptable action.

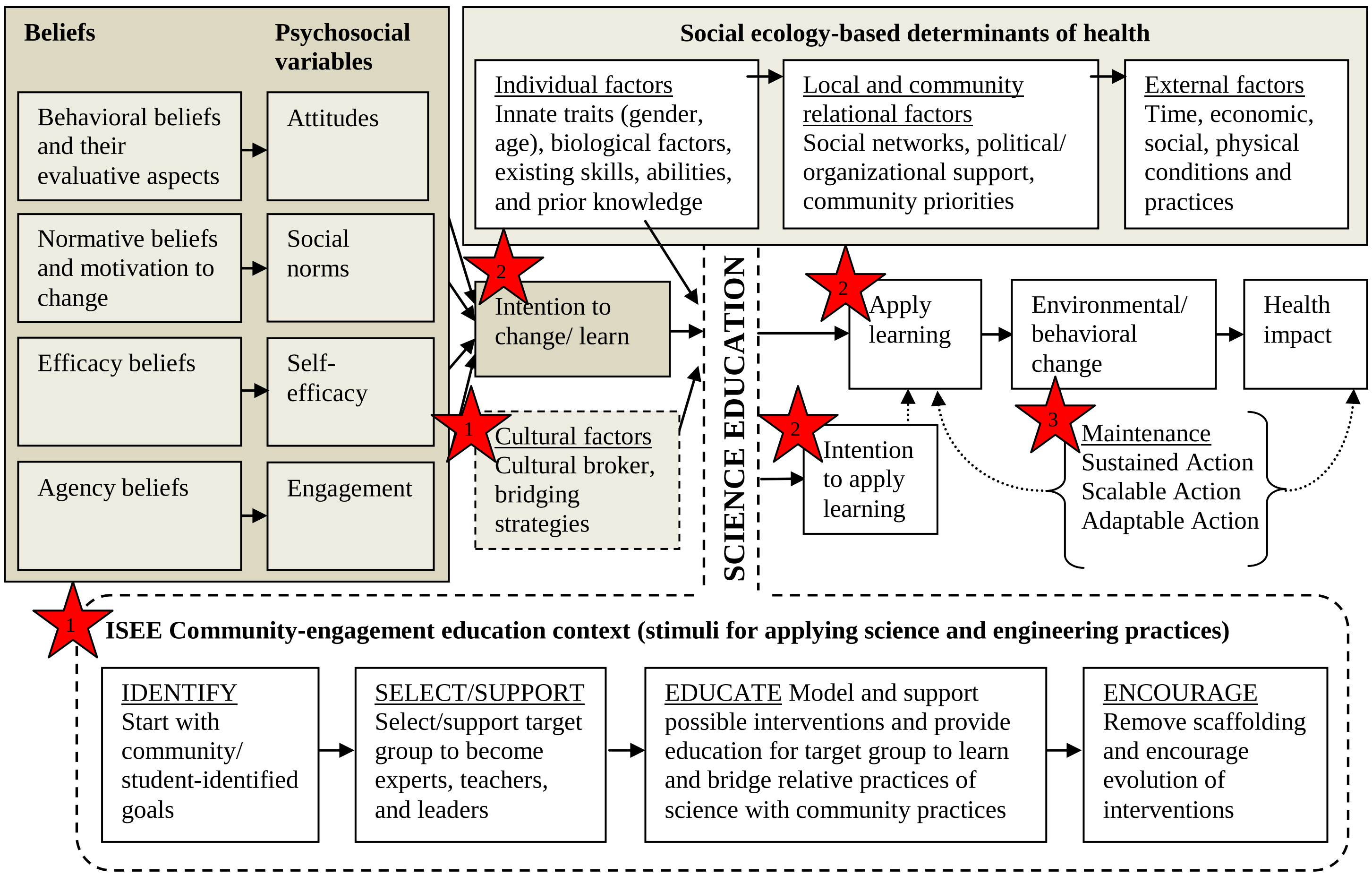


Figure 19. A community-engagement applied practices of science (CAPS) model toward education and community health improvement (Adapted from models suggested by Fishbein, 2000; Grizzell, 2009; Montano & Kasprzyle, 2008; Minkler, 2008; and Panter-Brick et al., 2006; and informed by evidence from this study). Stars indicate proposed data-driven modifications to existing models.

The following revisions in 7.2 describe the data-driven model adaptations used to develop the revised community-engagement applied practices of science (CAPS) model. The first revision discusses the science education intervention. This community-engagement education context is the proposed stimuli for applying science and engineering practices that lead to community health behavior improvements. This ISEE education context consists of four key components: identify, select/support, educate, and encourage (ISEE). The ISEE education context portion of the CAPS model is examined and then additional considerations for the CAPS model are made regarding moving from intention to action and for maintenance of the intervention.

Community-Engagement Education Context: Stimuli for Applying Science and Engineering Practices (I SEE). The first modification to the original model is the science education context including four activities toward community health improvement including: identify, select/support, educate, and encourage (ISEE). This set of activities that were done by the intervention providers, in this case Mme. Atieno and me, is described below and highlighted in Figure 20.

Identify (I). Before even starting the health club, the main goals for the program and research were co-constructed by community leaders, teachers, and the researcher. On the first day of the health club, students completed a pre-survey. One of the questions on the pre-survey asked students what they were most interested in learning about health. This question was then used to start a discussion about health in the community and what students wanted to learn and improve. While a student's interest in a given topic did not indicate that the

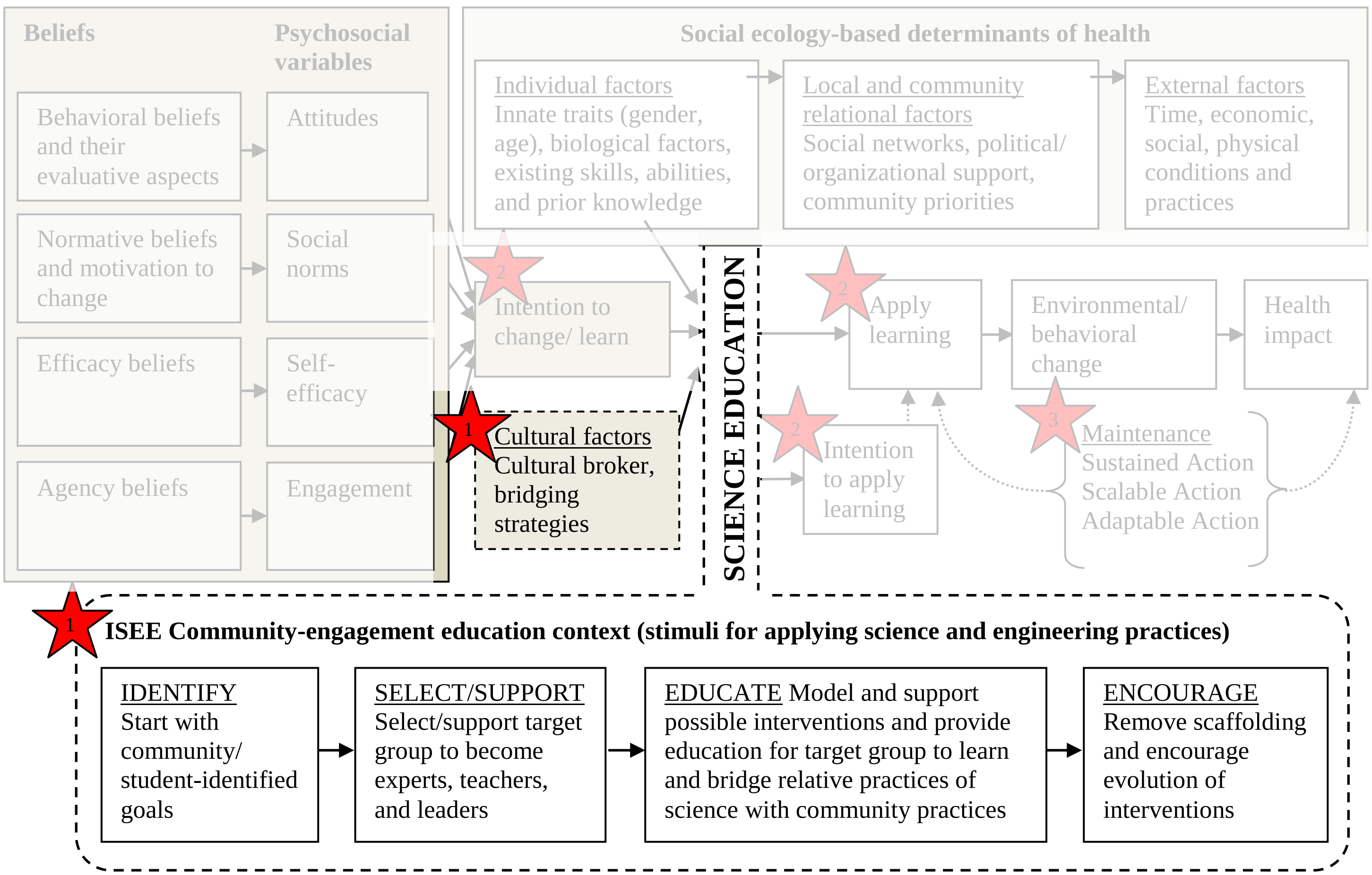


Figure 20. The science education component of the CAPS model: ISEE community-engagement education context (stimuli for applying science and engineering practices).

student was any more or less likely to apply their learning about that topic, the health club as a group was motivated to learn and to improve the community by connections they were able to make between their initial questions and the science and engineering practices they were learning. The process of identifying students' interests and discussing their observations of health in their community was one bridging strategy toward connecting their learning to the community.

Select/ Support (S). A group of primary school students in grades 5-8 were selected as the target group in this study by community leaders, local school teachers, and suggestions from students themselves. High school students were first identified as potential experts by community leaders, but they had a busy schedule and minimal connection with the local community as the local high school was a boarding school where students lived and studied. On the other hand, the primary students in this study were less likely to apply what they had learned during the course of the program. For immediate change in Namerokamano, as evidenced by the findings in this study, the ideal target group seemed to be primary students who were around 13-14 years of age.

As students, the target group in this study were identified by two of their teachers as having leadership skills, an existing interest in science or health, and time after school to participate. The students were seen as leaders in their respective grades who could easily share what they had learned in the health club with their other classmates. Most of the students felt comfortable sharing what they had learned with their peers and had the opportunity to do so. In rural villages in Kenya, there is often a shortage of teachers in schools. Because of this, students often teach each other. This cultural practice allowed us to select a target group of students who already showed leadership by teaching their peers in this way. Additionally, several students in the target group had younger siblings and substantial responsibilities at home indicating leadership roles in their families as well.

From these considerations, the target group was selected from students with potential and/or previous experience as teachers, leaders, and science experts. This optimized the chances that the target group would be able to apply what they learned in their community. Thus, a crucial part of the ISEE intervention is selecting a target group with potential to become experts, teachers, and leaders within their community.

Educate (E). In educating the health club as a target group for improving community health, the teacher and I focused on providing students with experiences to learn practices of science and modeled ways that students could apply their learning outside of the classroom. In integrating science education with community-engagement health models, the teacher and students serve as cultural brokers between science and community. In this process, teachers "craft new spaces within a community (new points of entry, new ways of engaging a culture) that makes participation possible" (Aikenhead, Calabrese-Barton, Chinn, 2006, p. 413). It is this role that helps the target group become leaders in community-based participatory research and action. Specifically, this research shows that an important aspect of educating students was in identifying and using bridging strategies to help students develop connections between their place-based interest/individual sense of place, community science/engineering practices, school science/engineering practices, evidence/design-based solutions, and place/community applications. These bridging strategies allowed students to develop confidence as experts, teachers, and leaders as they applied what they learned toward improving community health.

Encourage (E). As part of the health club, students were encouraged to apply their knowledge from the first day. This built-in feature was like scaffolding that was slowly removed over the six month program. First students were asked to teach someone their method for hand-washing. Later, they were asked to apply first aid if the need arose and use the balanced meals they had organized when cooking at home, but these assignments were not checked or enforced. Students later volunteered to test the water in their own home, brought their data to class to interpret, and were encouraged to share their findings with others. Toward the end of the program, students brought stories of their various applications to the health club and began encouraging each other.

In addition to encouraging students to apply their learning outside the classroom, students were also encouraged to adapt the health club to their needs. When they began noticing a lack of water to study and treat, students suggested that the club design a solution. The teacher and I helped the students to design a rainwater system and pitch the idea to the principal. The principal agreed to do the project if they found external funding for the tank (which was paid for by a local family and my own family) and recruited their parents to help with the labor. The students asked their families to help and the principal asked for small donations for any material costs. In this way, the students were able to adapt the health club to their needs. The teacher also helped the health club evolve and began planning activities to help students learn more about adolescents and healthy choices as needs arose in the school. A challenge with health interventions is that they are difficult to sustain especially in light of a community's changing needs. By encouraging participants to adapt the club to their needs early on, the target group will be more likely to continue improvements long after the program is officially completed.

These four stages (identify, select/support, educate, and encourage) together create ISEE as a science education context for supporting students' applications of learning toward community change. First, the education context includes identifying community or student-identified goals. Then, a group of people is represented to become the target group of potential experts, teachers, and leaders. Next, this target group is educated by providing structured opportunities to learn relevant scientific practices and their connection to community needs. Finally, scaffolding and support are slowly removed and people are encouraged to adapt interventions as new needs are identified

From Intentions to Actions. The next modification I made was adding additional pathways between intentions and change. Existing models tend to link directly between intentions to change. My data suggests that students had initial intentions in learning and making changes in their community, but that these did not always lead directly to action outside of the classroom. These intentions to learn and change also differed from later intentions to apply learning when mitigating factors also played a role in moving students' intentions into applications. Figure 21 above highlights these additional pathways from intentions to applications in the proposed CAPS model.

Even if a student intends to learn and intends to improve community health, this does not guarantee that the student will in fact be the agent of change and apply his or her learning toward improving the community. It also does not guarantee that the student will never apply what he or she learned toward improving community health. Younger students were more likely to have intentions to apply their learning and older students more likely to directly

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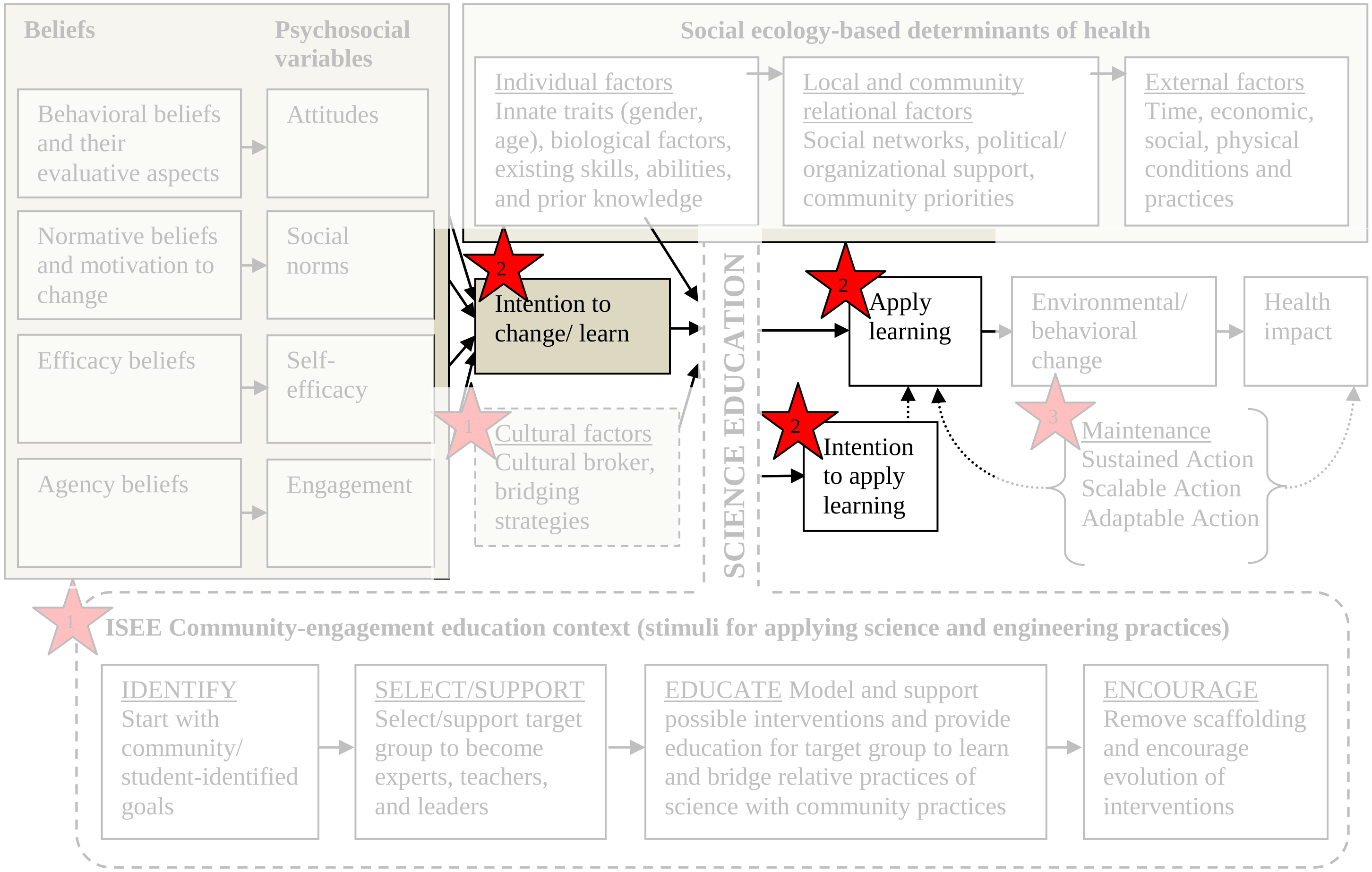

Figure 21. The intention and application components of the CAPS model.

apply their learning, which suggests that the younger students may apply their learning later. Some students also described intentions to act that were beyond their current capabilities. Though these future applications and issues of retention are beyond the scope of this study, students in focus group interviews explained that they planned to apply their learning someday even if they could not make all of the improvements they wanted to in their community at the present. Based on students' explanations, the proposed model includes a pathway from students' intentions to learn toward having an opportunity to learn and another potential pathway from students' intentions to apply their learning toward possible future applications.

Maintenance for Sustained, Scalable, and Adaptable Action. This final modification, shown in Figure 22, is included as a consideration was brought up by students and their teacher rather than initiated solely from data. As evidenced by interviews, students had future plans to apply their learning; there was also hope that applications toward improving community health that resulted from the science education intervention would continue to improve community health in the future. This would not likely happen without maintenance during and after the program. Such maintenance is crucial for sustained, scalable, and adaptable action. Some of this maintenance was built into the norms of the target group so that students felt ownership for the program and were motivated to continue applying their learning in the future and in new contexts. As Paul eloquently explained,

> This health club is not for only us. It is for us, the reason we have come here as health club members is to be taught and to be teachers of experts. So, we as teachers of experts we have our duties to perform by explaining and reasoning well why we

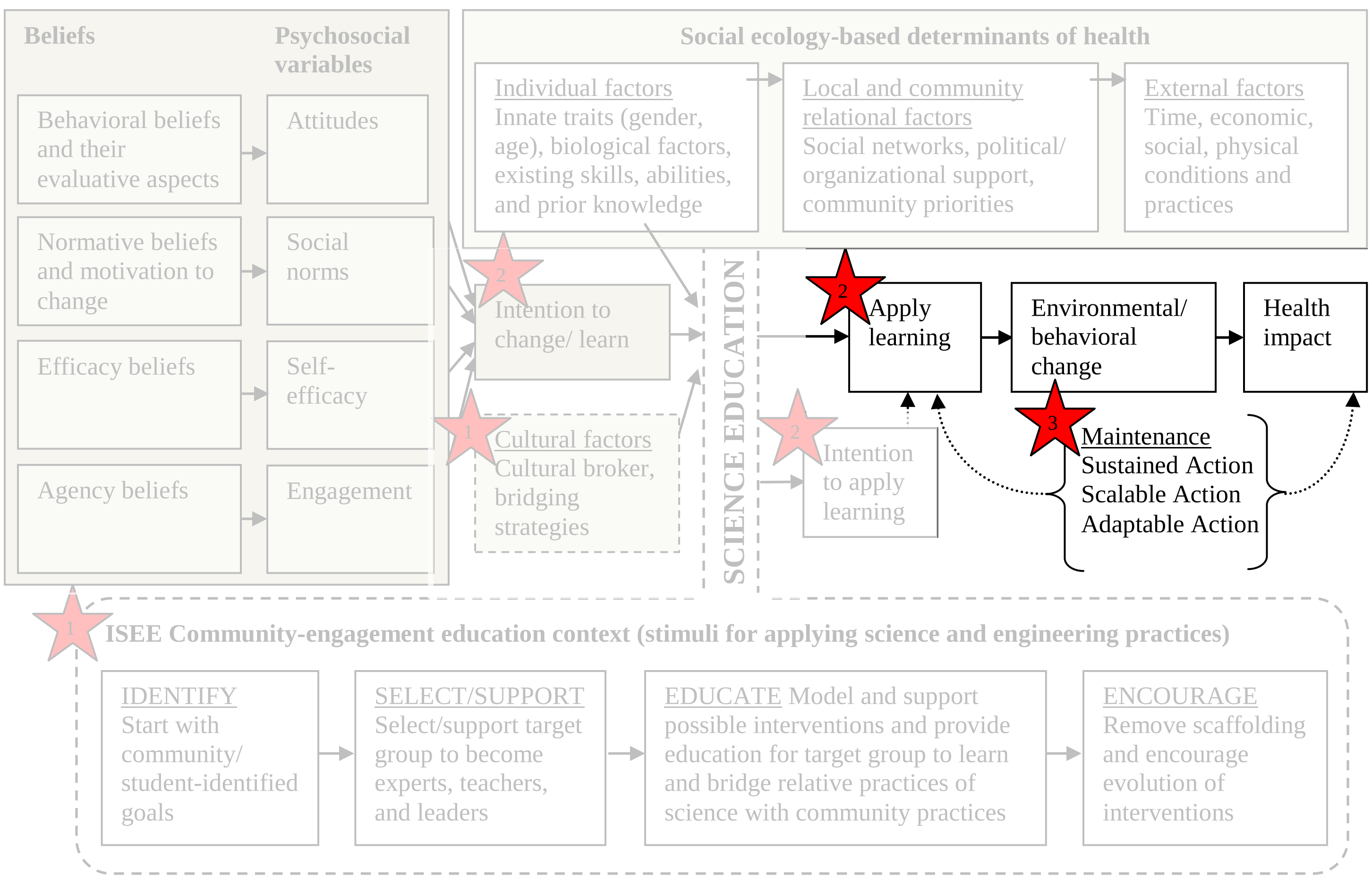

Figure 22. The maintenance for sustained, scalable, and adaptable action component of the CAPS model.

> should do these things and not do this and that to avoid unhealthy body, to avoid contracting many diseases, and even having bad health." (Paul, focus group interview)

The students not only learned science and engineering practices toward health applications, but established goals to use their expertise in teaching others. The teacher even showed evidence of scaling the program beyond the target group by adapting science lessons and teaching methods for use in her other classes. She felt that the practical experiments helped students make connections with the science. Additionally, students suggested that teaching new health club members or others in their community needs to be done with practical experiments rather than just explanations of what they learned. Students and Mme. Atieno were able to scale not only the science and engineering practices and health applications, but also teaching methods beyond the classroom.

While being scalable and sustainable are important goals for achieving maximum impact from health interventions, it is equally important to ensure that the target group is able to adapt their expertise, teaching, and leadership as new needs arise. Six months after this study was completed, informal interviews with teachers and students described how the health club had grown to meet new needs of the students. They said that most of the participants were still meeting regularly, and that they had recruited new members from younger classes since some of the health club members had graduated. The teacher explained that the club was trying to focus on sex education and science education that would support students going through puberty. She elaborated by explaining that students felt they had not learned enough in this area to prepare them to make healthy decisions as they become young adults. One year following the end of data collection for this study, I returned to visit and found the health club had also changed to meet the new needs of their students and school. Some familiar faces were still there and they explained that they renamed the health club "Child to Child" and their main role now was to use science about disabilities to help the new students at their school. The Namerokamano principal and teacher excitedly showed me new handicap-accessible latrines and explained that the health club was now responsible for educating the rest of the school on how to best support the school's new inclusion education practices for students with disabilities. As the health needs of the school and community change, a functional target group will be at the forefront of those changes still connecting science education to community needs.

What do the learning opportunities, applied learning, and factors suggest about models for applied science education and student-initiated health improvements? This research builds on existing community health models by (1) contextualizing socio-cultural perspectives into health behavior change theories, (2) applying community-engagement theories and integrating results, and (3) proposing strategies for incorporating science education and cultural bridging strategies as interventions toward improving community health. The resulting model, a community-engagement applied practices of science (CABS) model toward education and health improvement serves to conceptualize findings in this study and iteratively inform existing theoretical considerations for science and health education. The science education is divided into four steps to propose an integrated model for a community-engagement education context, a stimuli that allows students to become cultural brokers and apply their learning toward community health improvements. The ISEE model for a community-engagement education context includes: (1) identify community/student goals and target group, (2) select/support target group to become experts, teachers, and leaders, (3) educate by modeling and supporting possible interventions and providing opportunities for target group to learn and bridge relevant practices of science with existing community practices, and (4) encourage application of science and engineering practices and remove scaffolding supports. The CABS model also proposes potential movement from intentions to apply learning toward action and built-in maintenance to ensure that changes are sustainable, scalable, and adaptable to future community needs.

7.3 Implications for Science Education

This research provides insight into students' perspectives for what interests them in science, the context behind these interests, and how these can be leveraged in designing curricula. Science education can and should connect school science with community action and doing so has the potential to integrate science, engineering, and education toward improving community health. As Aikenhead explained in the conclusion of a discussion with Calabrese-Barton and Chinn, we need to shift to

> "science content or people (e.g., adolescents in high-poverty neighborhoods) who practice inquiry into nature as found in their community (science-as-practice)…we must move away from western science for its own sake and take up place-based science for the good of a community. Importantly, community practitioners are the ones who decide what science content is relevant ('functional science,' not the people who devise conventional standards-based curricula ('wish-they-knew science')." (Aikenhead, Calabrese-Barton, & Chinn, 2006)

While this is a crucial shift in focus to improve access and equity in science as well as improve communities, there is limited understanding in how this shift can take place in science classrooms.

The findings from this study provide strategies students and teachers can use to better connect place and community with science and engineering practices as well as a model for using science education toward improving community health. First, it is important that science education focus on the practices of science and science as performance since those practices are transferrable across cultural contexts. As Le Grange (2007) explained, “Science as representation refers to: abstractions such as theories and laws; the idea of a scientific method; descriptions of the world in textbooks; and so on. Science as performance, however, refers to the doing of science, that is, science is a human and social activity that is messy, heterogeneous, and situated” (p. 587). Understanding and emphasizing knowledge production as performance in the classroom enables the learner to negotiate and travel among communities of practice, or cross cultural borders which, as Aikenhead (2006) suggested, is necessary for learning science. Secondly, teachers can actively build bridges to better connect place and community to those practices and vice versa. These strategies and the model connecting science education and community health improvement will enable educators to actively bridge cultural borders and make science more accessible and meaningful to students’ local communities. These strategies are particularly useful since they do not rely on curriculum or policy changes at the school level for integrating science and place, rather strategies that teachers and students can directly employ. Furthermore, this study suggests a valuable connection can be made by integrating the fields of science education, cultural studies, and health education and can be mutually beneficial across these areas.

7.4 Limitations

This study was limited by the following: scope, limited resources leading to lower data quality, and cultural communication norms. The target group who completed both pre and post-surveys, participated frequently in the program, and participated in focus group interviews was only 20 students. This limited the type of analysis used and inferences that could be generalized to other students. Yet, the students were a small group and, as such, were able to frequently interact with the Mme. Atieno and me as well as access learning materials. In addition to limited scope with the target group, the community was similarly restricting in terms of scope for purposes of the research. Namerokamano was small, close-knit, remote, and culturally homogeneous; however, these features did allow me entry into the community and allowed for a more developed understanding of the cultural context than would have been possible in a community with a larger or more culturally heterogeneous population.

Data collection was limited by access to specialized equipment like microphones and electricity that would have improved data quality. While video equipment could be fully charged in town before going to the school, recording time was limited by battery life. Sound provided severe difficulties. Classrooms were divided by thin walls and occasionally classroom space was unavailable for interviews and outdoor background noise, especially from the wind, was substantial. Wind frequencies were subtracted from interview tracks after data had been collected, but some parts of interviews were still lost. Communication itself during interviews was especially difficult for girls. Cultural practices in the community, especially at churches and schools, dictate that girls should not speak up and should respectfully hide their faces. Even when girls did talk during interviews, they often placed their hands over their faces, making it difficult to hear their voices. A solution to this in retrospect would be to triangulate interviews and video observations that rely on speaking with student writing. Student diaries could provide additional data during the health club and reflections on what students learn and ways in which they apply their learning. Such methods would supplement interviews and allow more in-time exploration to determine which aspects of the science instruction led to applied learning. This would also help students who have more trouble with speaking in English since it would allow them time to formulate thoughts. The diaries could then be used as talking points during interviews and students could be asked questions to share and expand on using their diaries for language/memory support.

This study is also limited in that it focuses on students' perspectives and would benefit from comparisons with more concrete video observations or other evidence. Initially, I had intended to triangulate students' reports of applied learning with actual water quality that would also provide more evidence for ways in which students applied their learning. During the time of the study, though, Namerokamano was in its dry season with limited water availability. If research had been conducted during the rainy season, the school's main water source would have been able to be tested to see if students were making any changes in water maintenance, treatment, and storage. Since it was the dry season though, the school relied on multiple water sources, even desperately using lake water. Lake water has so much bacteria that it exceeds the limit of most available water testing equipment; however, this effect worked well in teaching students to compare different water sources. Though this lack of consistent water sources was a limitation of the study, it also allowed the students to adapt the health club to a need they identified as not having enough water. They then designed an additional rainwater system to meet this need and learned engineering practices along the way.

7.5 Future Directions

The health club has already begun evolving in new directions. Six months after the health club started, the students and teacher shifted the focus toward science that would help students better understand puberty and make healthy decisions. The school was building new latrines and discussions with health club participants led to the addition of a washing area for girls. For a while, the club did not meet frequently since Mme. Atieno was attending classes herself in special education though participants still had responsibilities to maintain school hygiene. More recently, the school became an inclusive school and added new students with special needs. Based on these needs, the health club evolved once again as a support group to use science education for learning about, relating to, and better supporting students with disabilities.

Like the school evolution of the health club, there were also health changes made at the community level. As Oroko brought up during the health club focus group interviews, one of biggest challenges to community health was waste management. “You can tell them after they use that water, to take rubbish and burn, so that water can put back to the lake. Sometimes they can are just start eating and leave the polythenes [plastic bags] and the rain comes and washes them to the lake. It is now quite dirty” (Oroko). When Oroko started at a boarding high school, his uncle began working to achieve his goals. His uncle created a Beachside Health Committee whose main goal was improving water quality. In two nearby towns, there were recent cholera outbreaks but because of the committee’s hard work educating people about the requirements for using safer sources and/or treating water to prevent the disease and new alternative sources of water at the health clinic, the town of Namerokamano managed to avoid cholera.

Future research should explore whether and how students' intentions ultimately become actions, more tangible health outcomes from science education interventions, as well as replicate similar studies in different contexts. These future directions would serve to explore the impact and generalizability of these findings and the resulting model. Specifically, more research is needed to study the use of bridging strategies to better connect place and science in the classroom. These strategies emerged from data in this study. While they were used by the teacher and students throughout the health club, they were not explicitly studied for their own sake. Further studies can intentionally apply these strategies to look at ways of improving accessibility of science education for underrepresented students and the role science education can play in community improvements. Additionally, the CAPS model should be further tested in new locations and sociocultural contexts to test and modify it based on new insights and findings. Most importantly, future research should build on conversations that will iteratively use such theories toward improving science education and community development. There is value in intersecting the two fields of science education and public health toward integrated development efforts and research with implications for both.

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APPENDIX A

Pre-Survey

1. What is your name?	My name is ______________________________.
2. How old are you?	I am ____________________________ years old.
3. What class are you in at school?	I am in standard __________________________.
4. Are you a boy or a girl?	I am a __________________________________.
5. What is your favorite subject?	My favorite subject is ____________________.
6. What do you want to be someday?	I want to be a ____________________________.

1. How can people become sick? (draw and explain)

____

____

____

____

2. What do you do to stay healthy? (draw and explain)

3. How do you wash your hands? What do you use to wash your hands? (draw and explain)

4. When should you wash your hands?

- ☐ Before I eat
- ☐ After I eat
- ☐ After I use the latrine
- ☐ When I am sick
- ☐ After I shake a sick person's hand
- ☐ Before I cook
- ☐ When I help someone who is hurt
- ☐ Other: ____

5. What can make you sick?

- ☐ Sharing food or drink with a sick person
- ☐ Getting bit by a mosquito who bit a sick person
- ☐ Getting bit by a sick animal
- ☐ Drinking dirty water
- ☐ Other: ____

6. During the last term, how many days did you miss school because you were sick?

- ☐ 1 or 2 days
- ☐ 3 or 4 days
- ☐ Between 5 and 10 days
- ☐ More than 10 days
- ☐ 0 days. I did not miss any school because I was sick.

7. What can make water dirty and unsafe to drink?

- ☐ Animals or insects drinking from the water source
- ☐ Sick people touching the water source
- ☐ Putting water in dirty containers (jerry cans, drums, pitchers, cups)
- ☐ Rain washing animal poop into the water source
- ☐ Rain washing chemicals into the water source
- ☐ Other: ____

8. Where does your family get water?

- ☐ Opanga pump
- ☐ Nyatembe pump
- ☐ Maurice Olela's pump
- ☐ Other groundwater pump
- ☐ Lake Victoria
- ☐ Viagenco's rainwater tank
- ☐ Other rainwater tank
- ☐ River
- ☐ Other: ____

9. How often do you sleep under a mosquito net?

- ☐ Every night
- ☐ Some nights
- ☐ I do not sleep under a mosquito net

10. What do you want to learn most about health?

____

____

____

____

APPENDIX B

Post-Survey

1. What is your name?	My name is ______________________________.
2. How old are you?	I am ____________________________ years old.
3. What class are you in at school?	I am in standard __________________________.
4. Are you a boy or a girl?	I am a ___________________________________.
5. What is your favorite subject?	My favorite subject is ____________________.
6. What do you want to be someday?	I want to be a ____________________________.

1. How can people become sick? (draw and explain)

2. What do you do to stay healthy? (draw and explain)

3. How do you wash your hands? What do you use to wash your hands? (draw and explain)

4. Name two reasons why it is important to wash your hands.

____

____

____

____

5. When should you wash your hands?

- ☐ Before I eat
- ☐ After I eat
- ☐ After I use the latrine
- ☐ When I am sick
- ☐ After I shake a sick person's hand
- ☐ Before I cook
- ☐ When I help someone who is hurt
- ☐ Other: ____

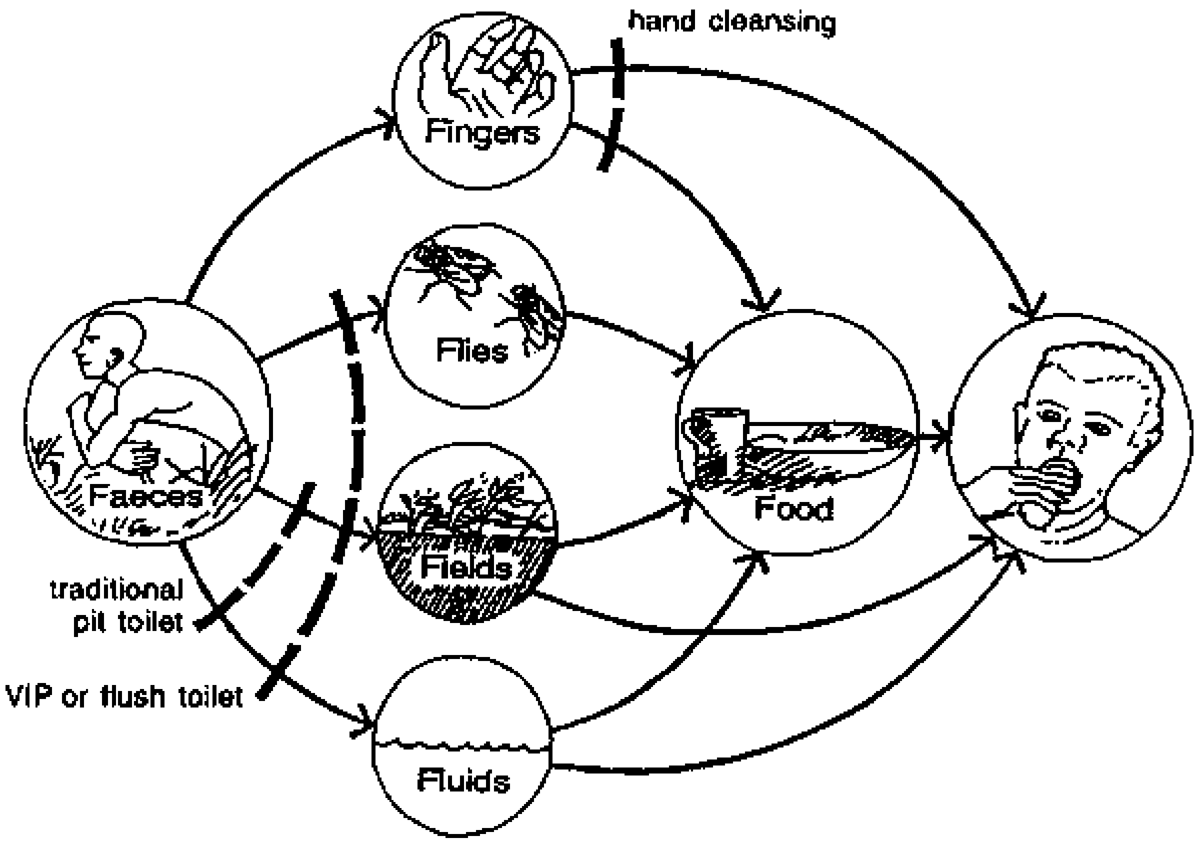
6. Who did you teach to wash their hands?

____

____

How did you teach them?

7. Looking at the F-diagram below, how do most respiratory and stomach germs spread?



What are some ways you can stop these germs from spreading?

____

____

____

____

8. What can make you sick?

- ☐ Sharing food or drink with a sick person
- ☐ Getting bit by a mosquito who bit a sick person
- ☐ Getting bit by a sick animal
- ☐ Drinking dirty water
- ☐ Other: ____

9. During the last term, how many days did you miss school because you were sick?

- ☐ 1 or 2 days
- ☐ 3 or 4 days
- ☐ Between 5 and 10 days
- ☐ More than 10 days
- ☐ 0 days. I did not miss any school because I was sick.

10. Name 4 infectious diseases (diseases that spread from person to person)

11. Name 4 non-infectious diseases

12. Describe one of the diseases you listed in question 10 or 11.

What can you do to prevent this disease?

What can you or a doctor do to treat this disease?

13. What is immunity?

14. Name the body cells responsible for fighting diseases?

15. How do these body cells fight germs that cause diseases? (draw and explain)

16. What does HIV/AIDS do to the immune system?

17. State five signs and symptoms of HIV/AIDS?

13. How can HIV/AIDS spread from one person to the next?

- ☐ Unprotected Sex with someone who has HIV/AIDS
- ☐ Protected Sex (using a condom) with someone who has HIV/AIDS
- ☐ Using a needle or syringe that has been used by someone who has HIV/AIDS
- ☐ Getting a blood transfusion using the blood of someone who has HIV/AIDS
- ☐ Shaving with a razor that has been used by someone who has HIV/AIDS
- ☐ Holding or shaking hands with someone who has HIV/AIDS
- ☐ Other: ____

14. What foods can you eat for dinner that would represent a balanced diet?

15. What is first aid?

15. What can you do if your younger sister has a fever (a high body temperature)?

16. What can you do if your friend cuts his leg and is bleeding?

17. What can you do if your nose is bleeding?

17. What can you do if your cousin is choking?

18. What is dehydration?

18. What is the procedure for making rehydration drink?

19. How confident are you in your ability to give someone first aid?

- ☐ Very confident
- ☐ Somewhat confident
- ☐ Not confident

Please explain your answer:

20. Who have you helped give first aid to and how did you help them? If you have not given any first aid yet, please say so.

21. Name three sources of water in the community?

Of these three sources, which has the most bacteria and is most likely to make you sick if you drink it?

23. What can make water dirty and unsafe to drink?

- ☐ Animals or insects drinking from the water source
- ☐ Sick people touching the water source
- ☐ Putting water in dirty containers (jerry cans, drums, pitchers, cups)
- ☐ Rain washing animal poop into the water source
- ☐ Rain washing chemicals into the water source
- ☐ Other: ____

21. Name five water storage facilities available in the community and school.

22. Where does your family get water for drinking?

____

____

22. How does your family treat drinking water?

- ☐ Filtering
- ☐ Boiling
- ☐ Water Guard or Chlorine
- ☐ Other: ____
- ☐ My family does not treat drinking water

24. How can you tell if water is safe to drink?

____

____

____

____

25. What can you do to make water safe to drink?

26. Describe one of the water research projects you or another student in the health club did.

What water was tested?

What were the results?

How can these results help improve the health and sanitation of your home?

27. How often do you sleep under a mosquito net?

- ☐ Every night
- ☐ Some nights
- ☐ I do not sleep under a mosquito net

28. What can you do to improve health and sanitation at your home?

How confident are you that you can make these improvements at your home?

- ☐ Very confident
- ☐ Somewhat confident
- ☐ Not confident

29. What can you do to improve health and sanitation at your school?

____

____

____

____

How confident are you that you can make these improvements at your school?

- ☐ Very confident
- ☐ Somewhat confident
- ☐ Not confident

30. What did you like most about health club?

____

____

31. Do you want to continue participating in health club next year?

- ☐ Yes
- ☐ No
- ☐ Not sure

32. If the health club continues next year, how can it be better?

33. What else would you like to share about your experience in the health club?

APPENDIX C

Focus Group Interview Protocol

1. What did you learn from being in the health club that you didn't know before about…?
    a. Hand washing
    b. Diseases
    c. Healthy eating/balanced diet
    d. First Aid
    e. Water
2. How can what you learned help improve the health and sanitation of …?
    a. Yourself
    b. Your family
    c. Your school
    d. Luanda
3. Have you shared anything you learned in health club with others?
    a. Who?
    b. What did you share with them? / What did you teach them?
    c. How do you think it helped them?
    d. If not, why not? Do you plan to share anything in the future?
4. How comfortable do you feel teaching others about health?
    a. Who do you feel comfortable teaching health to?
    b. What topics do you feel comfortable teaching?
    c. If you do not feel comfortable teaching, why not?

5. Have you used anything you learned in health club to make changes in your home?
    a. What?
    b. Any impacts?
    c. If not, why not? Do you plan to do this in the future?
6. Have you used anything you learned in health club to make changes in your school?
    a. What?
    b. Any impacts?
    c. If not, why not? Do you plan to do this in the future?
7. What did you like the most about health club?
8. What did you like the least about health club?
9. If the health club continues next year,…
    a. What changes should be made to the club?
    b. What else would you like to learn?
    c. What would you tell a new pupil about the health club?
10. If another school were to start a health club, what advice would you give…?
    a. The teachers?
    b. The pupils in the club?

APPENDIX D

Needs-Based Assessment Water Quality Data from Engineers without Borders

Parameter	2010	2011
Fluoride from borehole water (mg/L):	2.6	N/A
Fluoride from unfiltered tap stand (mg/L):	2.44	2.2
Fluoride from filtered tap stand (mg/L):	0.5	< 0.1
Fluoride from Lake Victoria	N/A	0.5
Total CFU from borehole (CFU/100mL):	60	30
E. Coli CFU from borehole (CFU/100mL):	N/A	10
“At-the-tap” total CFU from fluoride filter taps:	N/A	50
“At-the-tap” E. Coli CFU from fluoride filter taps:	N/A	10
Total CFU from Lake Victoria water (CFU/100mL)	>10000	
E. Coli CFU from Lake Victoria water (CFU/100mL)	594	

APPENDIX E

Applications and Intended Applications for Each Health Topic

Table E 1

List of Hand-Washing Applications and Intended Applications from Interviews (Broader Concept Counts Include Specifics Listed Below as well as any Concepts Listed More Generally)

Hand-Washing Concepts	Comments indicating application	Comments indicating intention to apply	Total
Wash hands…	5	6	11
With soap or running/pouring water	1	1	
Before eating/after using latrine	1	1	
Teach hand-washing…	19	14	33
To family	13	3	
To classmates/teachers	4	5	
To community	1	6	
Provide water for hand-washing	0	2	2
Total	24	22	46

Table E 2

List of Disease-Prevention Applications and Intended Applications from Interviews (Broader Concept Counts Include Specifics Listed Below as well as any Concepts Listed More Generally)

Disease-Prevention Concepts	Comments indicating application	Comments indicating intention to apply	Total
Prevent spread of disease…	6	12	18
Clean the environment/rooms	2	5	
Clean/cover/build latrines	2	5	
Cover food/windows	2	1	
Vaccinate	0	1	
Teach disease-prevention (e.g., cover mouth when coughing)…	5	5	10
To family	5	0	
To classmates/teachers	0	2	
To community	0	1	
Total	11	17	28

Table E 3

List of First Aid Applications and Intended Applications from Interviews (Broader Concept Counts Include Specifics Listed Below as well as any Concepts Listed More Generally)

First Aid Concepts	Comments indicating application	Comments indicating intention to apply	Total
Apply first aid…	6	16	22
Bleeding	2	3	
Nose bleeding	1	2	
Fainting	0	4	
Fever	1	2	
Choking	1	1	
Dehydration	1	1	
Teach first aid (e.g., Heimlich maneuver - 4, reducing fever, making rehydration drink)…	5	8	13
To family	4	1	
To classmates/teachers	0	1	
To community	0	2	
Total	11	24	35

Table E 4

List of Balanced Diet Applications and Intended Applications from Interviews (Broader Concept Counts Include Specifics Listed Below as well as any Concepts Listed More Generally)

Balanced Diet Concepts	Comments indicating application	Comments indicating intention to apply	Total
Maintain a balanced diet…	2	7	9
Buy food from each food group	0	1	
Eat a balanced diet	1	2	
Serve balanced meals	0	1	
Start a school vegetable garden	0	1	
Teach balanced diet (e.g., affordable proteins)…	7	9	16
To family	7	5	
To classmates/teachers	0	1	
To community	0	2	
Total	9	16	25

Table E 5

List of Water Treatment/Storage Applications and Intended Applications from Interviews (Broader Concept Counts Include Specifics Listed Below as well as any Concepts Listed More Generally)

Water Concepts	Comments indicating application	Comments indicating intention to apply	Total
Water treatment, testing, and storage…	8	18	26
Treat water for drinking/cooking	6	10	
Provide treated water	1	6	
Label water/place sign	0	2	
Cover water	1	0	
Waste water/watershed management…	0	3	3
Build latrines near lake	0	1	
Pick up/do not throw rubbish	0	2	
Teach water testing and treatment (e.g., not to drink untreated lake water)…	6	15	21
To family	5	6	
To classmates/teachers	0	3	
To community	0	6	
Total	14	36	50