The Potential to Integrate Computational Thinking into K-12 Health Curriculums

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Abstract

Health classrooms are an ideal place to educate the general population about using health technology and making positive health choices. In this paper we present an idea to bring Computational Thinking and technology to the forefront of health classrooms with two computationally enhanced lessons on food deserts and sexually transmitted infections (STIs). We discuss implications of a population educated with Computational Thinking and health technology skills and how the health informatics community can benefit from health technology in the classroom.

Introduction

Consumers use health technology to track health metrics, talk to their doctors, search for information, and find community. Despite using these tools, the majority of the general public lacks many of the skills necessary to use the technology effectively[1]. If the health community hopes to increase the adoption and use of these tools, we must educate the majority of people when they have the time and resources to learn. Almost the entire population passes through K-12 classrooms, making them an ideal place for this kind of education.

Some K-12 curriculums address technology literacy[2], however the extent of the coverage varies between districts and even between teachers in the same district. Some health teachers construct assignments that challenge their students to search for health information, while other health teachers provide the information directly to their students to better assess comprehension. Separate from K-12 classrooms, the health informatics research community has created research-based guidelines to help people use health technology effectively[3]. Although these guidelines can be distributed through public services[4], we ask, "How can the community widely distribute this information to consumers?"

Technology needs to be moved out of the periphery in health classrooms and become a central theme. Although exposing students to different health technologies is valuable, we suggest educators go beyond this and give students Computational Thinking skills as tools to make better health decisions. In this paper we describe a project to develop two health lessons that teach students about health disparities and sexual health in high school health classrooms. The WISH workshop would provide us an ideal venue to receive feedback from the health informatics community to improve our ideas before deploying and evaluating them lessons in the classroom.

Background

The idea of integrating Computational Thinking in health K-12 classrooms developed out of our work with the University of Colorado Boulder NSF funded GK12 project in Computer Science called Project eCSite[5]. Project eCSite faculty and graduate student fellows collaborate with teachers in 7 different K-12 subjects including Math, Art and Culture, Health, Civics and Social Science, Biology, Physical Sciences, and Computer Science. One of the project's goals is to bring Computer Science and Computational Thinking[6] into traditional K-12 classroom settings. Computational Thinking goes beyond simply integrating computers and technology into classrooms; it encompasses concepts around computation, such as graphs, abstraction, and recursion. Graduate student fellows are paired with K-12 teachers and spend 8-10 hours each week in K-12 classrooms observing teachers and students to identify areas in the curriculum to integrate computational thinking.

Graduate fellows work closely with the K-12 teachers, other fellows, and faculty members to build new computationally augmented lessons that fit into the curriculum already being taught. In our case, we met with, and will continue to meet with, two high school health teacher collaborators to understand the current curriculum and how we can best fit computational elements. We also looked at the health education guidelines for the district to make sure our lesson meets the needs of the teachers and students.

Augmented Health Curriculum

Based on conversations during initial brainstorming sessions, the health teachers mentioned two parts of the curriculum where they would like the most assistance – (1) nutrition – specifically helping their students understand the impact of nutrition on people with different available resources and (2) sexual health – specifically providing students the ability to understand the implications of their actions. In addition, the teachers discussed how they

would like to improve their students' ability to find and use information to make better-informed health decisions. We briefly present two lessons that can assist with the identified curriculum components and ideal skill sets. In addition, we detail evaluation plans for each lesson to assess the students' understanding of the materials and skills.

Food Deserts – Information Search and Data Interpretation

Obesity has become a major health concern among children and adolescents[7]. Health teachers educate students about nutrition to address this epidemic. Although instructing students about the right things to eat and how their body uses the food is a good starting point, students should be proficient in identifying information sources and using tools to help them improve their dietary decision-making. In addition, they should also be mindful about how an individual's environment, resources, and culture affect his dietary decision-making. We will collaborate with the high school teachers to create a lesson that exposes high school students to these experiences before they would in their lives. To this end, students will identify environmental, health, and socioeconomic data sources and aggregate the data in a visual mash-up to understand dietary decision-making from various points of view. Students will initially explore their own, well-resourced community and then compare their community with a local underresourced community, a food desert[8], to see how these factors can affect health outcomes.

The mash-ups will be interactive visualizations of spatial data overlaid on maps where students can control what data streams are displayed. For example, a student could enable the layer for obesity, which would show a color-coded intensity graph overlaid on the map with obesity rates in different geographic areas. Then, the student could overlay grocery stores and fast food restaurants in each area to see if there is a correlation between access to healthy food and obesity. Students will utilize publicly available data sets from the USDA (http://www.ers.usda.gov/Data/), NIH (http://www.nlm.nih.gov/hsrinfo/datasites.html) and other agencies to visualize this information with relevant context. During this exercise, students will see how computational tools, such as the mash-up, can help individuals make sense out of the rich data sets.

After students explore their own community to become proficient in searching for information sources and using the mash-up visualization, we envision students working in small groups to generate a hypothesis about connections between health status and other metrics. They will use the map mash-up to explore their hypothesis and collect data to either accept or reject that hypothesis. For example, students might explore is the link between obesity and average income. They might hypothesize that lower income contributes to increased obesity. To test whether this hypothesis holds true or not, they would enable the obesity prevalence layer and the average income layer, which would display information about both topics on top of the geographical map. They would be able to find areas where average income is low and look to see if obesity is higher there. The students would need to collect and analyze data from several geographical areas to test their hypothesis.

Ideally, this lesson would help students learn about the food choices in their own neighborhoods and identify actionable changes they could make to their own health habits. Students would also gain a broader world context. For example, they may learn that some neighborhoods do not have nearby grocery stores and thus are limited to eating fast food.

Sexually Transmitted Infection (STI) Propagation - Graphs and Networks

Sexual health education has historically been a sensitive subject with varying levels of coverage across classrooms including overviews of reproductive anatomy, protective measures, STIs and diseases. Simply knowing the names of STIs and facts about the infections does not necessarily help students make better choices or understand the implications of their decisions. This lesson will tackle the topic of STI propagation and sexual health utilizing computer science concepts – specifically, graphs and networks. The interactive curriculum will build problem-solving skills, knowledge, decision-making skills and self-efficacy around the topic of sexual health. Part of the lesson will utilize a web application that visualizes sexual activity networks as a graph where nodes represent people and edges represent sexual contact between two people. Students will use the web application to explore sexual networks, preparing them to build minimal risk networks applying their acquired knowledge and skills.

We will leverage current visualization tools[9] to build a web application that students can use to explore sexual networks. The application will show the impact of STIs on the network and the potential cost to the individual at the center of the network. For example, if the center of the network is a girl who is at high risk for pregnancy, the application will display statistics on college graduation rates and average income. We envision that students and teachers will manipulate variables, such as average number of sexual partners, point of origin, type of disease, and type of contact, to determine the impact on the sexual network in the visualization we develop. Teachers will

introduce the tool in the class where they can walk students through the manipulation of a sexual network. This will familiarize students with the concepts of networks, relationships, and STI transmission.

A directed assignment will lead students through identifying high-risk individuals, sources of infection, level of risk for contracting the STI, and rate of propagation for a given network. Students will work in small groups in a computer lab where they will be able to use the visualization web application to complete the assignment. After that activity, students will be tasked with designing a minimal risk network with the slowest propagation. They will work as a group to place and connect cut-out paper circles on the floor of the classroom to build a low risk sexual network. Each student will get one paper circle (around 5" in diameter) that represents themselves. Circles will be categorized as "protected," meaning they are using protection during safe sex to prevent the propagation; "abstain," meaning they are abstaining from sexual intercourse and therefore do not have to be connected to the network; or "unprotected," meaning they have unprotected sexual intercourse and could transmit an infection. The number of nodes in each category will be based on results from the local CDC Youth Risk Behavior Survey. Students who do not have an abstain node must connect their node to at least one other node with a string, however they can choose to connect to more. The class will strategically connect their nodes and place the "protected" nodes in such a way that the fewest possible people risk infection.

We will assess students understanding of sexual health, STIs, and graphs/networks by administering a pre-post survey to the students that completed this lesson and compare the results with students from another health class in the same school that did not complete the lesson. The health-related survey questions will be based on accepted sexual health testing material that is used to evaluate if learning objectives have been met. The computational skills component of the survey will include questions about a given sexual network, similar to the activity with visualization. In addition, it would be ideal if students could extend their gained Computational Thinking skills to other health subjects. Social networks are an obvious target, but more specifically the propagation and impact of gossip. Students will be given a problem to solve regarding a scenario where a secret has been shared among individuals and the goal is to figure out how far the gossip might travel within a certain amount of time. We will ask them to draw or describe their thought process in order to count the number of individuals that apply the network concept to the problem. The gossip propagation example will lead to an in-class discussion where teachers can reinforce self-esteem and ethical topics while exploring the gossip network with the visualization web application.

Discussion

Each of our lessons emphasizes different Computational Thinking concepts. The food desert lesson teaches information seeking, information synthesis, abstraction, and modeling to students. Because the students specify a narrow hypothesis at the beginning of the lesson, they need to find specific information relating to that hypothesis. Informaticians have developed strategies and guidelines to find authoritative information sources, which can be taught to students during this exercise. In this lesson students are required to take multiple data streams and relate them to build a higher-level understanding of the data. This higher-level understanding is an abstracted picture of the health situation in different areas. A key learning concept is that generalized, abstracted data has limitations - it does not represent every single person in a population. Even though an area has a high prevalence of obesity, it does not mean that every resident is obese or that there are no healthy people.

The STI lesson focuses on the Computational Thinking concepts of graphs and networks. Networks are a powerful way of thinking about relationships between multiple entities. There are many different problems and real life situations that can be thought of as graphs. Being able to understand the relationships between many elements in a network graph, in this case many people and their sexual relationships can help someone more fully understand their risks and implications of their choices.

Researchers have identified modeling (a computational thinking skill), problem solving, and social skill building as elements for successful STI education programs[10]. Because our lesson requires students to take elements of a graph (nodes and edges) to a specific state (a minimal risk network), they are solving a model of a problem that occurs in real life. Even the visualization itself is a model of real life situations. As students play with the tool, they will get the opportunity to model different scenarios and observe the outcomes. The collaborative element of answering questions with fellow classmates regarding the visualization and constructing a paper representation of a sexual network will draw conversations around the topic of sexual health. This will build student social skills specifically around this topic, hopefully making them more comfortable about discussing the topic among peers and adults. Computational Thinking offers a powerful set of tools health educators should consider teaching.

We closely work with the health teachers and learn about the approved health curriculum standards[2] to ensure the computational thinking lessons we create complement the topics and address curriculum learning guidelines, outlined in Table 1. Although the guidelines are specific to our collaborating school district, we are confident there would be overlap in other health education curriculum. Our goal was to develop lessons that fit into the curriculum already being taught in health classroom. By disseminating our lesson plans and supporting documents to our project website, we hope other teachers can utilize our ideas, adapting the lessons to their own unique curriculums.

Table 1. Health Curriculum standards addressed by our lessons

Guideline	Computational Thinking Lesson	How it is addressed
Analyzes influences on wellness decisions and practices health enhancing behaviors	Food Desert	Exploring the impact of diverse food choices on health status is an example of an influence of wellness. Students will see how moving to another area to eat might have profound impacts on health.
Distinguishes between wellness behaviors and risk behaviors	Food Desert and STI Propagation	Students will see that eating healthy is a wellness behavior that has positive outcomes. In the STI lesson students will see that all forms of sexual contact can be risk behaviors, but there are protective measures, which are wellness behaviors.
Identifies and practices health enhancing personal care habits and disease prevention strategies	STI Propagation	STIs are diseases that can be prevented with a variety of strategies that students will get to identify and experiment with in a modeled setting.
Identifies sexual risk behaviors, situations that could lead to pressure to engage in sexual activity, and common sexually transmitted infections and their symptoms	STI Propagation	Students will learn about various STIs in the visualization. They will identify differences in how the different infections are transmitted and propagate.
Analyzes influences on decisions regarding sexual and reproductive health	STI Propagation	Students will see how risky sexual choices can translate into poor sexual health outcomes.

We encourage the health informatics researcher community to consider collaborating with K-12 health teachers to broaden their user-base and confirm their research. K-12 collaborations offer a potential environment to evaluate technological interventions or develop design guidelines based on needs analysis for target youth populations. Researchers could test the effectiveness of health interventions or applications while at the same time exposing students to useful tools and strategies for health management. Likewise, these studies could assist the teacher in addressing curriculum needs – such as having students assess their personal diet.

Our idea has the potential to create a more educated population around the topics of health and health technology. People may slowly gain a Computational Thinking skill set that helps them identify relevant health information to make improved health decisions. Like any topic in education, there are limitations to our ability to deliver knowledge to people. Much like high schoolers that graduate with elementary school reading levels, we cannot expect to reach every student. However, it is worthwhile for the health informatics community to think about what a more skilled population might mean for our future research agenda.

Future Work

Our team is in the process finalizing the design of the module with a plan to pilot a subset of the concept with 3 health classes at one school during Fall 2011. We will follow the pilot with a full deployment and evaluation in high school health classrooms at two different schools during Spring 2012.

Conclusion

Computational Thinking is a powerful skill set that can aid people in finding health information and making health-related decisions. The ideal place to begin educating people about Computational Thinking is health classrooms as part of the curriculum that is already in place. Exposing students to health technologies is a start, but ideally students would be learning health topics through thinking computationally. We proposed two computationally augmented K-12 health lessons for teaching nutrition and sexual health to high school students. The health informatics community could benefit from this project by witnessing the potential for integrating research and informatics into formative K-12 curriculum.

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