Restructuring 207 (placeholder title)

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**ABSTRACT**

In Grinnell College students get introduced to CS through a structured three course multi-paradigm sequence. Seeing the success CS1 and CS2, that use media computation and robots, respectively, to teach functional and imperative programming, have had with enrollment and student satisfaction at the end of the course, it was due time to incorporate a more motivating technology, and not just the Eclipse IDE, into CS3, that teaches object-oriented programming in Java. Recent studies [2] have shown that students are more likely to enroll in courses pertaining to socially relevant issues, which is why we have decided to restructure the course. Out hope is that with the introduction of a relatively fresh technology – mobile application development on Android, and an overarching theme of computing for social good – with the help of the Ushahidi platform, students will learn how to solve complex and relevant problems with computing with an exciting technology that will ultimately enhance their learning experience and convince them to pursue computing more in depth.

**Categories and Subject Descriptors**

K.3.2 [**Computer and Education**]: Computer and Information Science Education Features – *Computer science education, Curriculum*

**General Terms**

Design, Experimentation, Languages

**Keywords**

Computer science education. CS3. Android. Ushahidi platform. Object-oriented programming. Java. Course materials. Lab-based course. Interdisciplinary approaches.

# INTRODUCTION

This paper describes a reconstruction of the last course in a three course multi-paradigm CS introductory sequence taught at Grinnell College. Our goal is to incorporate tangible software development techniques, under an overarching theme of computing for social good, in a course that introduces students to object-oriented programming.

WRITE MORE STUFF

# CONTEXT

## Motivating Technologies

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Computer science educators have been introducing motivating technology into introductory computer science courses is a technique to reach out beyond an existing negative computer science stigma, such as the negative opinions documented in [12]. Their goal is to motivate students to take the courses, to engage them throughout the course, and encourage them to take future computer science courses. In [1, 11], robots are programmed through code written in C and C++. In [6, 10], students learn to write Android applications, and program them using Java and the Android API. In [7], manipulating music is presented as an application. In every case, the motivating technology makes the course more engaging for the students.

## Computing for Social Good

Unfortunately, incoming students who have no previous computer science experience are often under the misconception about what a computer science course or major actually entails. Studies have shown that freshmen tend to avoid taking computer science classes because they think they’re boring, tedious, and irrelevant [3, 12]. Not only that, but students, especially females, tend to choose majors that are easily relatable to social good [2], which is something they don’t associate with computer science. This is why educators have recently tried to incorporate the theme of computing for social good in introductory computer science classes. As such they can provide students with meaningful and tangible projects that have an impact on society, and give them an incentive to continue their computer science education.

## Introducing Version Control Systems

Even though version control is essential to software development, very few CS courses actively emphasize and require their use [4]. Another misconception about CS, is that it’s a very solitary field. By introducing students to version control systems early on, we hope to both teaches them good software development practice, and show them how many CS disciplines require a collaborative team effort. By doing so we hope to disprove the aforementioned misconception and promote the idea of teamwork.

# MOTIVATING TECHNOLGOIES

In the early stages of our project we decided to incorporate a new technology and theme to our CS3 course, in order to provide students with a tangible technology for which they can program, and a theme that motivates them, and gives them the opportunity to impact relevant issues. This would provide a natural transition from CS1 and CS2, whose workshop style teaching has proven to be very successful. In May 2013 we sent out surveys to students and faculty, to give them a chance to be a part of our decision to restructure the course. More than 80% of the survey takers were most interested in incorporating mobile development with an overarching theme of computing for social good. In order to teach them how “real-world” software development works, we decided to give them a fairly open-ended collaborative final project where they work closely with a client, and apply what they’ve learned about using a version control system throughout the course.

## Android

In the past few years, the revolution of mobile computing has made software development much more accessible. It is our hope that students, having used mobile phones for most of their life, will find programming for the platform stimulating and exciting [10]. Because Android is natively based in Java, and as a mobile framework, very object based, it was a clear choice. The GUI design gives students tangible objects they can work and play around with, which reinforces the aspect of object-oriented programming, the ultimate pedagogy goal of this course.

## Ushahidi Platform

The Ushahidi platform is an open-source software that was released in 2007. Its goal is to collect relevant information about a certain topic through crowdsourcing to visualize the information on an interactive map. It was first used in the Kenya’s 2007 presidential election to collect reports of violence and voter fraud via email and text message, to place them on a map, thus informing and educating the public of corruption that was happening around them. Even though it can be used to gather any kind of information, Ushahidi deployments tend to address pressing social issues. Each Ushahidi deployment provides a large data set of reports. Each report has many different attributes, so it essentially alludes to an object. Because data structures and efficient data processing is a very large part of a computer science education, Ushahidi provides a great collection of motivating data that students can manipulate.[[1]](#footnote-1)

## Final Project

Another thing our surveys showed was that professors and students have a desire to work on a project with a client earlier on in the CS curriculum. Working with the department of Service Learning and Engagement, we were able to find a number of interesting projects that students could be able to initiate on campus (wellness/self-care and accessibility), in the town (the Chamber of Commerce, Drake Public Library, the United Way…) and with faculty (Sociology, Prairie Studies, Leisure…). The final project is going to include:

* Students working in a team of 3 or 4 people
* Decide what issues they’re going to tackle and find a client
* Create an Ushahidi deployment pertaining to that issue
* Work with their client to understand what best suits their needs
* Educate the client on how to maintain their deployment

A few example final projects might include reporting on:

* Racial incidents
* Transportation in Grinnell
* Failures of “Self Gov” 1
* Client mapping

## Git

We chose Git as our version control and source code management system to be use in CS3. We decided on Git because of its flexibility, relative ease of use, and speed. We wanted to use an SVN that has all the functionalities that we require, but one that would not add too much overhead to the already packed course. There are many pedagogical and student benefits to using Git [5]. Educators can keep better track of student work via Git than via email, they can easily identify potentially bad work habits, and better collaborate with their students. At the same time, students learn to work better in teams [9], they are more motivated to submit assignments on time, and they ultimately build essential skills for their future careers.

# COURSE PLANNING

## Course Goals

In order to develop a curriculum using the selected motivating technologies and themes, we compiled a list of goals for the course:

* Introduce object-oriented programming
* Introduce algorithms that maintain and manipulate data structures
* Involve students in computing for social good
* Teach students how to set up a basic Ushahidi deployment, and how to collect usable data from it
* Teach students how to design and develop a basic Android application

## Semester Outline

|  |  |  |
| --- | --- | --- |
| Topic | Course Hours | Topics |
| Developing in Java | 4 | Using an IDE; Git verison-control; Javadoc, Unit Testing, Debugging; Java Syntax |
| Object-Oriented Programming | 4 | Classes vs Objects; OOD principles; OOP in Java; Basic I/O |
| Android Development | 4 | Android development; Making a simple app; |
| Arrays | 4 | Arrays; Loops and iteration; Catching exceptions; Linear vs Binary search; Big-oh analysis |
| Linked Lists | 8 | Interfaces, abstract classes, generics; linked lists; Collections API |
| Linear Structures | 8 | Stacks, queues, priority queues; Sorting algorithms |
| Trees | 4 | Trees; Binary search trees; tree traversal; |
| Heaps | 4 | Heaps; Binary heaps; Heapsort |
| Other Data Structures | 4 | Hash tables; Sets; Dictionary |
| Final Client Project | 4 | In class final project development time. |

# PROJECT DEVELOPMENT

We selected three motivating technologies to use in CS3: Android, Ushahidi, and Git. We went on to develop course work and supporting software. Android is the platform upon which the students will be developing their programs on. We developed coursework and weekly assignments that used Android to teach students object-oriented design concepts and data structure algorithms. Ushahidi is a webserver platform that students will use to access large datasets. We set up an Ushahidi deployment to provide a motivating data set, and wrote an API for students to easily access the data. Git is used as a version-control system, so that students can manage their large projects. It is also used as a means of distributing and submitting course work. We redesigned CS3 to incorporate these technologies.

## Technology Experimentation

After some initial experimentation, we discovered ways in which the technologies can be organically incorporated in the curriculum. They will be used to enhance the CS3 experience, in a fashion that will not distract students from the core topics of object-oriented design and data structure algorithms.

## Introducing Git

We wanted students to familiarize themselves with Git, and develop a habit of using it regularly. We introduce Git in the first week of the course. We wrote several comprehensive readings and accompanying laboratory exercises that thoroughly explain:

* What version control systems are
* How to use GitHub
* Git specifics through examples (via terminal and Egit)

Students will be responsible to fork weekly projects posted on the class’s GitHub account, and submit them by sending a pull request. The instructor will then look at their code, and evaluate it accordingly. When the students are working in teams, they will have to create a joint public repository.

## Establishing an Ushahidi Server

Students will use Ushahidi as a means to access data. Students will learn to pull information from a server running the Ushahidi platform. They will also learn how to set up their own deployment to collect a custom set of data.

First, we established an Ushahidi server within a virtual machine, using Oracle’s VirtualBox. VirtualBox was run on a 2011 Apple iMac. The virtual machine runs the Xubuntu Linux distribution. We documented the instructions on how to set-up a virtual Ushahidi server.

Afterwards, we set up a dedicated machine to run a server for us. We installed the Xubuntu operating system onto the machine, and set up another server. The server was established on an HP Compaq 6200. This server will be used as an exemplar Ushahidi deployment, and as a source of motivating data. It will also be used throughout the course to organize data.

An alternative method for establishing and Ushahidi deployment is to host one on a website called CrowdMap. CrowdMap was developed and maintained by the same team who develops Ushahidi. CrowdMap allows a user to set up a basic deployment of Ushahidi, running on CrowdMap’s servers. CrowdMap has abstracted Ushahidi servers to be simple and easily maintained. However, through investigation, we found that CrowdMap did not support many features that our team found vital to the course we were designing. Ultimately, we chose not to use CrowdMap in our redesign of CS3.

## Developing an Ushahidi Java API

One of the reasons we incorporated Ushahidi in CS3 was because it gives our students access to large and diverse data sets.

The Ushahidi server stores all of the reports that are submitted as “incidents”. Incidents are composed of fields, such as the title, description, location, and date. These data sets of incidents easily lend themselves to objects. We can get these incidents from the Ushahidi server through an HTTP web API. However, the web API returns incidents in a text format called JSON.

We would like students to not have to deal with the HTTP or JSON. This prompted us to work on a new API that would be able to send an HTTP request, receive JSON data, and translate the JSON data from the web API into Java objects. CS3 students will understand basic Java, and will be able to handle these objects.

Our API is divided into two libraries. The first library, the UshahidiClient, gathers all of the approved incidents from the Ushahidi server, and stores each incident as a Java object in an ArrayList. An iterator is provided to traverse the ArrayList. UshahidiClient is also able to delete incidents from the local ArrayList. However, this library cannot be used to delete incidents stored on the Ushahidi server.

The second part of our API, called UshahidiAdmin, gives the user administrative privileges on the server. UshahidiAdmin was designed with the expectation that the students would set up their own Ushahidi servers. UshahidiAdmin collects all of the unapproved, pending incidents on the server. These pending incidents are hidden from UshahidiClient because it does not have administrative privileges. The UshahidiAdmin will gather pending incidents stored on the Ushahidi server, translate them, and store them as Java objects in an ArrayList. An iterator is provided to traverse the ArrayList. Unlike the UshahidiClient, UshahidiAdmin's delete method deletes incidents from both the local ArrayList and the Ushahidi server, and is able to do so for both approved and unapproved incidents. UshahidiAdmin also comes with an approve method that will approve the incident on the Ushahidi server and within the local ArrayLists. It is our hope that by using this API, the students will be able to comfortably interact with an Ushahidi server in their Java code, without distracting them from the core topics of the course. On top of this, using the API will give the students experience objects with which to internalize the concept of object-oriented programming.

## Designing Android Course Material

A major challenge we faced in redesigning CS3 was incorporating Android mobile application development, without adding too much overhead to an already dense course. The realm of mobile application development is fairly complex, and not beginner-friendly. After some failed experimentation with MIT’s AppInventor, and writing wrappers, we decided it was best to provide the students with readings and accompanying laboratory exercises in a weeklong introduction to:

* The Android SDK
* Creating an Android Project from scratch and what each generated file is used for
* A holistic overview of using XML for the GUI

We immerse students in Android development for a week, where they explore and create apps with our guidance. By the end of the week students should be familiar with basic Android app development practices, and know how to manipulate both the Java code and the XML code to achieve simple functionality. At the end of the week, we present them with a larger-scale skeleton app, which sets up the structure for their projects in the following weeks.

They start out with a basic “Annoying Kitty” app, where they put an image of a cat on the screen, and a button, that when pressed, produces a meowing noise. The following projects deal with data manipulation such as sorting and searching with different data structures. Students will be able to verify their efficiency, and figure out what types of data processing they’re best used for.

## Final Client Project

By providing students with a solid knowledge of Android development techniques, and presenting them with different Ushahidi deployments, the final project is supposed to be more or less student-driven. We want them to think about what social issues they want to address, and then provide them with the means of finding a client who could benefit from their idea. For the final project students will work closely with Department of Service Learning and Engagement. If they get stuck during the process, we’ll provide them with some initial ideas, but our intention is for the students to make the decision about what they want to impact.

## Reorganizing Course Material

The schedule and organization of topics in CS3 that has been traditionally used will no longer meet the needs of the courses. Originally, CS3 introduced the topics of object-oriented programming and data structure algorithms with few additional topics.

The new redesign will involve Git, Ushahidi, Android, and a final client-based project. Other topics will be shifted around to make room for these newcomers.

The weekly Android assignments will cover different topics than the original weekly assignments. This means that topics will not be introduced in the original order.

# INTERACTING WITH GITHUB

In order for others to benefit from our research and the course material we’ve developed, all of our readings, laboratory exercises, the Ushahidi API, the Android skeleton app, and any other relevant information are available through GitHub under the account Grinnell-CSC207.

We chose GitHub because of its widespread popularity, ease of access, and friendly user interface. It’s also the version control system we’re promoting in the course itself, so to use anything else would be entirely hypocritical.

# CONCLUSIONS AND NEXT STEPS

Motivating technologies and themes have been shown to interest students in an introductory computer science course, and enhance the course experience. [REFERENCES] In response, we have designed a curriculum for a CS3 class that uses Ushahidi and Android technologies and enforces computing for social good.

It is valuable to introduce introductory computer science students to version-control systems. The curriculum introduces students to the Git version-control system. Students use Git to participate in class and organize a large final project.

Previous research has shown that the theme of computing for social good should also attract and motivate students who would not otherwise take an introductory computer science course. [REFERENCE] Using this theme, we are also able to naturally include a client-based project into an introductory computer science course. Being involved in a computing for social good project allows students to envision motivating applications for computer science.

We used GitHub to organize our developed course material throughout this project. The latest version of our course material can be found online at [REFERENCE].

From here, we plan to test our curriculum in the field. The professor, student mentor, and students taking the course will all be responsible for providing valuable feedback. Participants will submit reviews in the style of [REFERENCE]. Using this feedback, the curriculum will be revised, and tested again. Revised versions of the curriculum will also be posted online.

Overall, we have redesigned a class, which introduces object-oriented programming and data structure algorithms, and included motivating technologies and computing for social good. Our evolving course material is publicly-available online.

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1. Grinnell College's concept of Self-Governance encourages members of the school to take responsibility for the health of the community by basing decisions on individual choice and personal accountability. [↑](#footnote-ref-1)