Chapter 5

Design of Hip-Hop Data Module

> *"We build computers and programs for many reasons. We build them to serve society and as tools for carrying out the economic tasks of society. But as basic scientists we build machines and programs as a way of discovering new phenomena and analyzing phenomena we already know about. Society often becomes confused about this, believing that computers and programs are to be constructed only for the economic use that can be made of them."*
>
> — A. Newell and H. Simon

One of the approaches that has been suggested to help maximize participation in CS, is an emphasis on interpreting and using information via computational artifacts. During its ideation process for the invention of the new AP CS principles framework, the College Board toyed with the idea of including a data project as part of a portfolio of work students created to demonstrate their knowledge of computing. Unfortunately, they later decided to exclude it.

Even though College Board eventually decided against the inclusion of a data module in students' portfolios, what is important about that line of inquiry is the acceptance by a panel of CS education experts on the importance of understanding data manipulation techniques as a fundamental skill of CS.

While data manipulation techniques are important, they are a means and not an end; the end is gaining knowledge and insights out of data. My friend and esteem colleague, John Denero, puts it best in his introduction of a new undergraduate course "Foundations of Data Science" at UC Berkeley, Fall 2015. He states his rationale for creating the course as follows:

> "We wanted to put together a set of ideas that will allow people to make informed decisions using data in this data rich world in which we live" (DeNero, 2015).

The power of data manipulation techniques come to light when they are directed in service of CS as scientific inquiry. These techniques allow the computer scientist to transform into a researcher, asking questions and creating epistemology about society; finally giving us the opportunity to build a bridge between intuitive understanding and formal knowledge.

This data module was specifically designed to help students understand the role of computer science as inquiry by guiding them through a scaffolded series of activities which investigates a "Hip-Hop" way of knowing through the computational exploration of rap lyrics. In addition, the philosophical assumptions of this research has been the notion that education/learning should have cultural resonance, should be "fun," and should be deeply embedded in society. Together these assumptions help guide the design of the Hip-Hop data module (Miller, 2014). The Hip-Hop data module as been implemented in the BJC curriculum as the final lab exercise of CS10.

5.1 Computer Science as Scientific Inquiry

In my opinion, one of the major reasons why students have a difficult time wrestling with data in the context of CS, is a lack of understanding of CS as scientific inquiry. To put it more precisely, a failure to grasp the *science* of computing.

As part of this research, I have spent time asking undergraduate CS students to tell me the difference between a "Computer Scientist" and a "Programmer." It has been interesting but not surprising to learn that most students don't know what distinguishes these two titles.

I believe the fault sits squarely on the shoulders of the academy. In many institutions, the CS department sits under the departmental structure of the Arts and Sciences, and in other institution, its seats under the college of Engineering. The reason for this is that computer science is both an *art* as well as a *science* (Knuth, 1974; Roy and Haridi, 2001). Most students don't think of the field in this way, the idea of CS as a science is not relatively new; however, it isn't explicitly discoursed.

So if CS is both an art and a science, then what exactly is the *art* of computing, and what exactly is the *science* of computing? In his essay *Computer Programming as an Art*, Donald Knuth posits that *art* in this sense is the application of knowledge, whilst *science* as it is used in computer science stands for knowledge, i.e., what we know (Knuth, 1974). What Knuth doesn't mention is the third leg of this knowledge stool, the question of how we know? And that, is acquired through the process of scientific inquiry.

The curricular intervention that is at the heart of this research speaks to the notion of computer science as scientific inquiry (Newell and Simon, 1976). The great leaders of computer science—Herb Simon and Allen Newell—believed that CS was an experimental science, that

every machine and in our case, every program written is an experiment that poses a question to nature and its behavior offers clues to the answer. Our hypothesis in answering these questions are what guides us in our construction of the program. This approach is brought ever more to light with the newly constructed field of data science.

As scientist, we build programs to investigate new phenomena or analyze phenomena with which we are already familiar or have a hunch about. All the while, understanding the tentative nature of science, the notion that it exists in a social context, and that it is an ongoing activity that involves uncertainty and subjectivity.

A significant way learning occurs is through play and exploration. When children are engaged in play, they are ostensibly engaged in extending their knowledge base of the world. This concept of exploration as a function of learning is used in some artificial intelligence learning algorithms to help programs discovery interesting patterns or just to learn about their problem space. Similarly, CS students as data scientist have to do the same thing. They have to learn to play with and explore data.

When we are out in the world, we always perceive phenomena in the environment, just like children. Some of these phenomena appear to capture our interest more than others. It is these that we decide to inquire about when we create our hypothesis, conduct our experiments and derive our theories. The idea of **"why"** is one of the essential aspects of scientific inquiry. The whole idea that drives research is our need to learn. In a way, scientists are just like children. One might go further and say that a good scientist should have childlike curiosity.

The transition from exploration to in depth study of the phenomenon is the transition from undirected learning to directed learning. At the heart of scientific inquiry lies three questions (Metz, 2004; Reiser et al., 2001):

1. How do we know what we know?
2. Why do we believe it?
3. And what exactly do we know?

These three questions are the superordinate frames from which scientific inquiry must be understood (Sandoval, 2005). This same three questions guide us in gaining meaningful insights from the computational exploration of data.

How Do We Know, What We Know?

This first question deals with explanation driven inquiry, where we attend to how and why things occur as they do. This is what people often think of when they think about the scientific method. It is usually motivated with the paradigm of rule discovery. It is also

what is generally understood by the inquiry cycle which starts with a question we want to answer. We start by formulating a hypothesis or making a prediction, then we design an experiment to confirm or refute our hypothesis. Based on the data that is collected from the experiment, a model is suggested or built, which leads us to apply the newly derived knowledge in context, that leads to another question and the cycle begins again (White and Frederiksen, 1998).

In this view of inquiry, we have to let students know that it is an open-ended exploration instead of the neat little "acquisition of facts" model of science they are used to. That there is no "right" answer, only exploration and knowledge acquisition. On breaking this conditioning, Papert pulls an example from the world of arithmetic and physics education, he states:

> "When computers are used to cure the immediate symptom of poor scores in arithmetic, they reinforce habits of dissociated learning. And these habits which extend into many areas of life are a much more serious problem than weakness in arithmetic. The cure may be worse than the disease. There is an analogous argument about physics. Traditional physics teaching is forced to overemphasize the quantitative by the accidents of a paper-and-pencil technology which favors work that can produce a definite "answer." This is reinforced by a teaching system of using "laboratories" where experiments are done to prove, disprove, and "discover" already known propositions. This makes it very difficult for the student to find a way to constructively bring together intuitions and formal methods."(Papert, 1980b, Chp. 4, Pp.139)

In a world where students have been conditioned to believe learning is getting the right answers on a test, or that writing code is mostly for app development, helping them expand their understanding of programming beyond that has to be an end in and of itself.

Why Do We Believe What We Know?

The second questions that lies at the heart of inquiry is being able to defend why we believe as we do. The naive view of science as a settled stable enterprise leads to confusion in the public when scientists argue about the validity of a theory; even though, the history of argumentation is an essential part of what makes science, science (Driver et al., 2000).

Argumentation and reflective inquiry gives us a mechanism for evaluating new knowledge claims. Since science is done in a social context and derives from the subjective view of individuals, this leads to an implicit bias towards "theory-ladeness" (Kuhn et al., 2000). For this reason, observations alone cannot be good enough to evaluate a new claim. This is where argumentation comes in, it is through the defense of ones claim that the warrants are laid bare and can be examined and cross examined by the community until a common consensus is reached with regards to the new knowledge. As was shown in section 4.3, with

race-based policing, based on algorithms that have codified human biases, reflective inquiry provided a mechanism for evaluating the knowledge claims.

Furthermore, through the use of computational data techniques, some researchers are using data gathered through other means to give a more nuanced understanding of the idea of "Black Criminality." The data scientist, Ben Casselman, from Nate Silver's[1] FiveThirtyEight.com states that:

> "As we've written repeatedly, official statistics on police killings are deeply flawed. So the Guardian is building its data set by combining media coverage, reader submissions and open-sourced efforts like Fatal Encounters and Killed by Police, which we've previously found to be reliable" (Casselman, 2015; Five Thirty Eight, 2015)

The data gathered through this approach is open-sourced and freely available through their Github repository. In addition, other data can be submitted to the collection, where the community can verify its authenticity and merge it into the existing datasets. The hope is that a clearer picture can emerge on race-based policing through experiments that are done on these kinds of community developed databases. Through experiments like these, learners can see that CS taken as scientific inquiry can have a profound effect on society.

Argumentation in particular is part and parcel of professional software engineering practice. Through the process of "code-review," software engineers have to justify the approaches they use in writing code. In open-source communities where coding is a collaborative community process, argumentation becomes one of the main processes by which pieces of code are patched backed into the main codebase. For novices, this process of arguing can be quite a cultural shock, because many novices are not used to being on the receiving end of the sometimes sarcastic and debilitating verbal shotguns that some engineers are particularly fond of.

What Exactly Do We Know?

The final question at the heart of scientific inquiry is determining the extent of the information that we know, i.e., theory elaboration. Theory elaboration is the process of identifying as many instances of a hypothesis that support a particular theory. This form of scientific inquiry is not often discussed, as it ought. It is from this line of questioning that we build a healthy corpus of data that will eventually completely elaborate a theory.

Now that I have laid out what is meant by scientific inquiry as applied to CS, I want to use the next section to discuss the motivation and creation of the Hip-Hop data module.

[1]Nate Silver is an American Statistician whose blog FiveThirtyEight uses statistical analysis—hard numbers—to tell compelling stories about politics, sports, science, economics and lifestyles.

5.2 Building a Hip-Hop Data Module

My main goal in building this piece of curriculum is to build a bridge between **formal knowledge** and **intuitive understanding**. This is really what data science *is*. As the curriculum designer, my main goal is to create a learning pathway where intuition can flow, and the learner can rely on their own knowledge of the world and their own assumptions, to guide their exploration of embedded knowledge in data.

An approach like this will ultimately lead to a connection between cultural relevance and computing, because each student will have to pull from their pre-existing knowledge, and their own cultural ways of knowing; as a curriculum designer, this is where I can really leverage the diversity of human experience to highlight how computation can refine our specific ways of knowing. To demonstrate my paradigm of data science as the application of formal methods to evaluate intuition, I will now turn my attention to the genesis of the Hip-Hop data module.

Hip-Hop Data Module: Exploration and Play

It all started in 2005 while I was working as a research assistant in a semantic web[2] lab. For many people, when they think of Hip-Hop[3], they don't think artificial intelligence. I, on the other hand do. At the time, I was embedded in a research group that designed and built ontologies, which forced me to adopt an epistemological framework. As a result, I found myself thinking a lot about the development of knowledge. This coincided with a time that I was listening to a lot of rap music, particularly Jay Z.

Everyday I would drive to the lab listening to his music, spending inordinate amounts of time trying to divine the meaning of his lyrics and their implications. There was a particular line in *03 Bonnie and Clyde* that always puzzled me. It went:

> The problem is
> You dudes treat the one that you lovin'
> With the same respect
> That you treat the one that you humpin'

The implication of those lyrics was the person, who was the object of the man's affection, was not the same person with whom the man was sharing his bed. I would often wonder how that line could be parsed and then ran through an intelligent system, which could clearly explicate the implications of the statement.

[2]From Semanticweb.org, The Semantic Web is the extension of the World Wide Web that enables people to share content beyond the boundaries of applications and websites. It has been described in rather different ways: as a utopic vision, as a web of data, or merely as a natural paradigm shift in our daily use of the Web.

[3]Hip-Hop is the culture—encompassing dancing, graffiti, rapping and so on, while rap is the musical aspect of the culture.

Over the years, my love of Jay Z did not diminish, and I was able to see the evolution of thought in his lyrics. The same man, whose lyrics once spoke about being in love with one person and sleeping with another, was now also talking about the miscarriage his wife endured and the birth of his daughter.

As a result of doing semantic web research, I started to see rap lyrics as a computational object to think with; what Papert terms "transitional objects" that gives a bridge from the intuitive to the formal. I experienced something I like to think of as "cognitive cross-over." I started to imagine the kinds of things that could happen in the mind of the scientist when formal computational techniques is brought to bear on a lyrical text analysis of rap music.

Hip-Hop Data Module: Hypothesis

Through my prolonged exposure to rap lyrics, I developed a hunch that emcees—rap poets, have a unique way of knowing that is derived from their expertise as persons who study language, persons who are highly skilled in the art of *Signifying*, and particularly, in the use of novel conceptual metaphors. That was the hypothesis.

What needed to be done to verify this hypothesis was to come up with an experiment that could test it. In order to do that, I first had to explore existing data to see how rappers use language. Upon my initial investigation, I realized that there were no open-sourced rap lyric datasets. If I wanted to do this experiment, I would have to invent such a dataset.

In 2011, when I began my initial inquiry into this space, while there were no rap lyric datasets, there were a plethora of music lyric websites. To narrow my focus, I decided to limit the investigation on Jay Z's use of language. I built a webscraper in Python, and scraped together all the lyrics of Jay Z that were in existence at that time. Once I had that initial dataset, I could then start my inquiry into his use of language. These trains of thought were the genesis of the development of this module.

The investigation was deeply embedded in society, had cultural resonance with me—after all I am an avid fan or rap, and was most important "fun!" As with all good curriculum, there was an emotional connection with the work, which enabled the experience of delight in the process of discovery (Newell and Simon, 1976).

Why Rap Analysis is Good for Maximizing Participation

Unlike say atmospheric datasets from NOAA[4], with Hip-Hop, we have a topic that has strong emotional resonance with most people because it is *polarizing*. It's one of those evergreen topics for which most people have a strong opinion. They either hate it or they love it. Its one of those topics that has something for everyone. For the feminist, they can mine it to demonstrate that it has higher rates of misogyny than other genres. For the fans of poetry,

[4]NOAA - National Oceanic and Atmospheric Administration, Datasets: https://data.noaa.gov/dataset/international-comprehensive-ocean-atmosphere-data-set-icoads

they can mine it for its novel use of language. For the cultural critic, they can mine it to get the pulse of what young people are currently into. Most importantly for ethnic-minority youth, it can be used to regain a sense of cultural pride through CS education.

Table 5.1: Why a Rap Data Science Module is Particularly Tantalizing?

1	Data is a part of APCS Principles big idea as can be seen from table 2.3.
2	Its an avenue of engagement for youth in an increasingly global world.
3	It's metaphorically ladened and semantically dense.
4	It provides a great opportunity to bring in issues of gender in general culture, especially misogyny in Hip-Hop.
5	Its an easy way to inject *CS* into *culture*.
6	Could potentially be used as ethno-computing CS curriculum.

Several qualities contribute to Hip-Hop's effectiveness as a potential computational object to think with. Hip-Hop is part of the natural landscape of many youths of color. It is a field that was pioneered by ethnic-minorities, and a field in which ethnic-minorities excel. My hope is that through works like this, the association of some ethnic-minority youth with education as a vehicle of cultural loss can be regained through positioning CS education as a vehicle for cultural exploration.

Hip-Hop lyrics are metaphorically ladened (Crossley, 2005; Peplow, 2010), they are sufficiently semantically dense and are open to multiple layers of interpretation; allowing wiggle room for each student to explore their own understanding. Table 5.1 lists the reasons why the computational exploration of rap is tantalizing.

Because it resides at the intersection of computer science and culture, the hope is that these kinds of learning contexts will potentially engage students. If as Papert posited and Piaget theorized, that intellectual knowledge is built upon already existing ideas and schema students already possess, then incorporating concepts from mainstream youth culture should help enliven curriculum that is culturally relevant and resonant (Piaget, 1964).

Hip-Hop Data Module: Design Constraints

According to Papert, *powerful* ideas have to be:

Intelligible. Learning should be in "mind-sized" bits, i.e., knowledge should be easy to grasp. For this reason, the data module deals with answering one question, "How does Jay Z use the language of 'basketball' in his lyrics?" That is it. That simple question is what the data module is interested in investigating.

General. The knowledge gained from learning should be applicable over a large domain. Having reflected on the results of the data module experiment, a learner should be able to apply the same methods to a larger corpus of rap lyrics to determine whether the finding in Jay Z's lyrics can be generalized over an entire rap corpus. More importantly, the techniques *learned* in conducting the experiment should be easily transfered over to textual analysis of other kinds.

Personal. Learning should not lead down the road to disassociation has we have seen in environments that pose a threat to student's learning. By grounding the data module in rap lyrics, I seek to follow this guiding principle by bringing in a cultural genre that most youth a familiar with.

The fully elaborated lab can be found in appendix A of this work. I follow the learning with data computation framework of Dasgupta to guide the creation of this learning module, I extend the computational framework to include visualizing data (Dasgupta, 2012). Furthermore, I model elements of the module to correlate the data science workflow—figure 5.2, that is usually used in industry as can be seen in table 5.2.

Hip-Hop Data Module: Curriculum

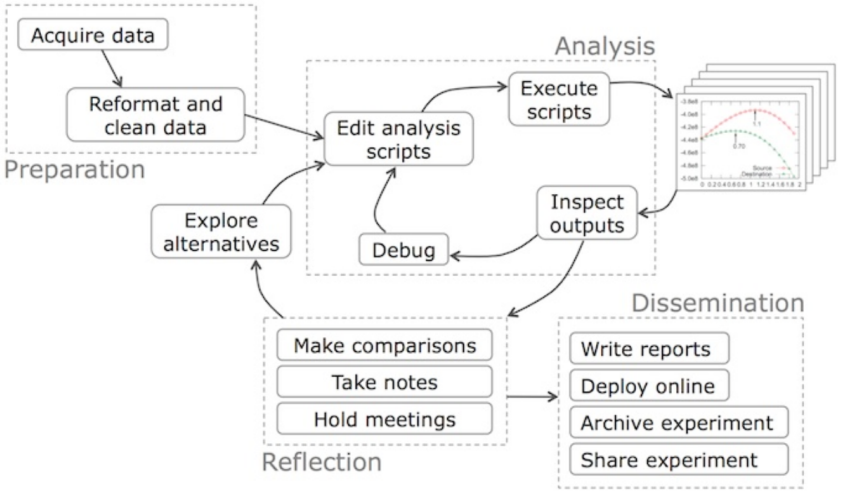

Figure 5.1: Data Science Work Flow diagram by (Guo, 2013)

Objectives

The student will be able to

- Come up with an question they will like to investigate through the exploration of data

Table 5.2: Mapping Data Science Work Flow to Hip-Hop Data Module

Tasks	Sub Tasks	Realization in Hip-Hop Data Module
Preparation	Acquire data	A.3, The learner is tasked with building a corpus.
	Reformat and clean data	A.4, A.5 The learner is exposed to the idea of stemming data to make conceptual investigations more scalable.
Analysis	Create analysis scripts	A.5 In this part of the lab, the focus is on formalizing intuition by first understanding the relationship between the layers of abstraction that store the data.
	Inspect output	A.5 Once the query is written, here the lab focused on the nuance interpretation of the output based on inspection of data plots.
Reflection	Make comparisons	A.5 Through the creation of a concordance, the learner is ushered into a mindset of reflecting on the output of the data.
	Take notes	Outside of the scope of the lab.
Dissemination	Write report	Outside of the scope of the lab.
	Share experiment	

- Write an algorithm to query a dataset
- Build a visualization of the results of a dataset query

Outline of Lesson

- Introduction to Data in Python
  - Welcome to computational lyrical analysis using Python
- Introduction to NLTK package
  - Getting familiar with the Natural Language Toolkit
- Creating a Jay Z Corpus
  - Corpus Reader
- Frequency Analysis

  - Determine the number of unique words used within an artist's first 35,000 lyrics

- Data crunching versus gaining insight? When Data Science runs amok
  - Lets investigate basketball concepts in the corpora

Big Ideas

- "Computational thinking" is the metacognitive process that attunes to the way we solve problems through the use of computational methods. It can apply to both machine dependent and machine independent processes.
- Python is a language suitable for scientific computing.
- After learning one language, the few languages you learn will be much easier. What you're learning is "how to learn". In the case of CS10, "The Beauty and Joy of Computing,"you started your computational problem solving journey using Snap*!*, now we have transitioned to Python. While Snap*!* was a graphical block based language, and Python is text-based, what is of most importance is that they are both languages that can be used to realize computational solutions.
- Python is well suited for text analysis because of its powerful nltk (Natural Language processing) toolkit.

Activities

- Investigate an idea in literary corpora.
- Learn the basics of Python text analysis and data manipulation, including file io.
- You should be comfortable with elementary techniques of natural language processing.

Discussion of Data Module: Empathy

To a certain extent, one could argue that the data module that I designed perpetuates the same dissociated learning paradigm that Papert rails against. However, what makes the approach I have taken different is that the series of exercises are an opportunity for learners to see how this kind of thinking is done. It isn't merely a data science tutorial, but more an experiential peek into the mind of a data scientist as they bring formal methods to bear on their intuition.

Lyrical exploration can be used to create a cognitive social connection. You can project yourself as the rap poet composing the lyric, carefully playing with words so they have double meanings based on context. You can *intuit* your way into figuring out how to find

these clever gems. Most importantly it forces you, the data scientist, to take the point of view of another person, and try to experience the world through their words; automatically taking you away from being "egocentric" to being "altruistic."

Discussion of Data Module: Cultural Resonance

This data module is also an exercise in helping students get exposure to different ways of knowing by investigating language use. This is particularly important in CS because its an approach that allows for a non-confrontational way to talk about diversity—in this case, diversity of thought.

Picking up the thread of thought from chapters 1.4 and 2.2, I had outlined the following concern.

> "In the CS context, computational thinking presents a tantalizing opportunity for culturally responsive pedagogy. Because of its recent ascendancy, there is very little research both empirical and theoretical on how culturally responsive pedagogy that supports computational thinking can be done." - Chapter 1.4

This data module demonstrates how culturally responsive pedagogy can be realized in a computational thinking based curriculum. This module specifically positions computation as a means of investigating culture.

I want to emphasize that I do not claim that there is an "African American," or "Asian American" way to teach CS, but more importantly, that *even* CS with its layers and layers of abstraction and mathematical complexity, can be used as an object of cultural inquiry.

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