Ethnocomputing: a mental model approach to the design and assessment of computational thinking in a culture-based learning environment

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A Candidacy Proposal submitted to the Doctoral Committee in partial fulfillment

Of the requirements for the Doctoral Candidacy Examination.

Major Subject: Multidisciplinary Science

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June 2013

Contents

Abstract

The United States has a serious problem in Science, Technology, Engineering, and Mathematics: these STEM disciplines are suffering from a 'Quiet Crisis' [19] in which African Americans, Latinos, and Native students have lower academic success rates and lower levels of career participation in the STEM disciplines than do their white and Asian counterparts. [5] We refer to this disparity as underrepresentation. Significant forms of inequality are always objectionable on moral grounds, but underrepresentation has negative practical implications as well. Underrepresented students failing the academic success that would have allowed STEM careers suffer from the loss in earnings that those careers would have provided. Society also suffers from this underrepresentation by having fewer people trained in the scientific method, and acting as role models in their community. STEM-trained professionals would be a force for good in educational achievement and healthy life style choices, as academic achievement is correlated with lower rates for HIV infection and substance abuse, and higher rates for vaccination. [10, 27]

There are different solutions for countering STEM academic failure and career avoidance, which we find by looking at the different potential causes for underrepresentation. In the context of learning, cultural determinism is the pernicious belief that the culture someone comes from determines their ability to succeed in academically rigorous subjects such as Science, Technology, Engineering, and Mathematics. Genetic determinism is the equally pernicious belief that one's genetics determines the students' ability to succeed in STEM. Both are at their worst when a student believes and internalizes each of these notions. Thoughts such as "I don't have the math gene", "My mom (dad) hated science", "no one like me knows how to program a computer", all serve to undermine student ambition and thus positive student outcomes in STEM.

I propose to look at how using ethnocomputing**,** specifically in the form of Culturally Situated Design Tools (www.csdt.rpi.edu) can counter the myths of cultural and genetic determinism. Ethnocomputing as I define it here is the simulation of indigenous and vernacular cultural practices in computer software. The development of this software is not a trivial undertaking, as it requires a convergence between abstract, generalized design considerations such as Vygotsky's "zone of proximal development" [21], and Resnicks "low floor and high ceiling" [29], with very detailed specifications for GUI behaviors in relation to user interaction.

One of the important objectives of ethnocomputing is the development of computational thinking in students. [7] However assessing how well this has been achieved is less clear-cut than for subject areas such as math or science, where a large body of practice on assessment of K-12 learning is already in place. Resnick and Brennan have attempted to assess student learning on the Scratch programming system through project portfolio analysis, artifact-based interviews, and developing design challenges that test a student's ability to use the Scratch software. [9] In this study, I look at the application of these evaluation methods to the Culturally Situated Design Tools and consider the addition of a mental model approach**,** which is both an aid for formulating assessments which determine how much a student has learned from using the CSDT

simulation software**,** as well as a framework for understanding the learning process in relation to cultural content and the student's own identity.

Introduction

The United States has a serious problem in Science, Technology, Engineering, and Mathematics. These disciplines, collectively referred to as STEM, are suffering from a 'Quiet Crisis'. [19] The problem is that African Americans, Latinos and Native students choose careers in the STEM disciplines at lower percentages than their white and Asian counterparts, and exhibit rates of academic success that further limit these choices. [5] In addition, this lower participation rate extends beyond ethnicity to gender resulting in a gender gap. [5] This disparity in STEM participation rates leads us to consider African Americans and Latinos/Latinas as underrepresented in the STEM disciplines.

Underrepresented groups have a profound effect on the US labor pool, by reducing the available candidates for STEM employment. This in turn affects US national and economic security by increasing US reliance on non-US STEM professionals. [19] From the potential employees' point of view, STEM avoidance reduces earnings potential and standard of living, which affects youth as well as their wider community.

As Jackson pointed out in her essay, the rate at which STEM professionals in the US are retiring exceeds the rate at which replacement workers are being educated and trained. [19] This disparity will have a profound effect on the availability of workers in the STEM labor pool in the United States. The effects of this worker shortfall are often countered through the extension of H-1B visas to foreign born STEM trained professionals. [2]

The resulting gap of trained STEM professionals represents a danger to both the national and economic security of the United States. [19] In particular, the threat to the national security of the US is most acute. For example, the shortage of US born STEM trained professionals directly impacts our ability of the United States to maintain a strategic nuclear deterrence program. [4] The need for knowledgeable employees in this area results in the rehire of Department of Defense employees after retirement in order to fill these open positions. [4]

STEM avoidance and Economic Security

In terms of the economic security of the United States, STEM trained professionals are not only tasked with maintaining sensitive information systems, but also in the design of new, cutting edge technology. Non – US citizens working in such positions pose special risks when it comes to new, patentable technologies that they may help to develop. Although technology developed here may be covered under legally binding patents and non-disclosure agreements, these workers will eventually return to their home countries. The knowledge that these STEM professionals will take home with them when their work visas end, will be fair game to competitors in countries where US patents and intellectual property claims are too difficult or costly to enforce. [1]

When we consider the effects of portions of the US population choosing to avoid STEM careers, it becomes clear that the cost of doing nothing in motivating and training students to be successful in STEM is just too high. As Jackson observes, to address this shortfall, we must be able to recruit STEM trained employees from the entire population. [19] It is vital to the both the economic and security interests of the United States that all US students view the STEM fields as desirable career options.

STEM avoidance and poverty

In addition to its effects on the composition of the STEM labor pool, avoidance of STEM fields of study has a profound impact on poverty. One of the most important decisions a young person can make is their choice of career. Once a career choice has been made, and presuming the student stays within this field of choice, adult lifetime earnings potential will have largely been determined.

Unfortunately, underrepresented students tend to choose careers in business, sports, or entertainment over the STEM fields. [3] The impact of these decisions on students is profound. In addition to determining lifetime earnings potential, a choice of a career in sports or entertainment provides little guarantee of actually making that potential. The sad fact is that students choosing these fields are far more likely to fail in their chosen profession than succeed, as very few people become a star athlete or entertainer.

On the other hand, for a student that sees a STEM field of study as a viable career choice, the impact on poverty is also profound. Choosing STEM greatly increases the lifetime earnings potential of the student, which in turn effects family members and significant others that are connected to that student. This choice for STEM would have a positive impact in alleviating poverty and eliminating the cycle of dependence so many underrepresented young people experience.

Countering STEM avoidance

Succeeding at countering STEM avoidance in career choice would yield benefits that would extend beyond the individual STEM professional. Students choosing STEM would be trained in the Scientific Method with its emphasis on critical thinking and problem solving, which would have a positive effect on those around them. These professionals would form the basis for a community that is both STEM informed and STEM aware.

STEM trained professionals would become positive role models for others within their community. This modeling of the benefits of a STEM education would encourage others to reconsider their STEM options. As the community grows in its STEM awareness, benefits would extend beyond the effects of educational role models. This expansion would have positive impacts on reducing the rates of teen pregnancy, which frequently robs young women of their ability to complete an education by adding overwhelming family responsibilities to their already difficult lives.

A STEM aware community would have lower rates of HIV infection, through its knowledge of the causes of that disease, and the risks of unprotected sexual activity. Knowing the causes and risk factors of HIV would encourage young people to stand up to peer pressure to engage in those risky behaviors. [27] STEM awareness would also assist health care professionals in guiding patients to make healthier lifestyle choices. In addition, STEM awareness would result in higher vaccination rates, which would increase positive health outcomes in all age groups. [10]

Research Question

What contributions can educational software make towards addressing the problem of low participation and academic performance by underrepresented groups in the STEM disciplines?

Finding a solution to this problem is not a trivial task. Many people have worked very hard at finding a solution, and still the problem persists. As we look for possible solutions, it will help to look at some of the causes of career choices that exclude the STEM fields, and causes of the academic achievement gap. Looking at this problem from the macro level of society, we can see that lower participation rates for underrepresented students in STEM may be influenced by the insidious myths of cultural and genetic determinism.

The myth of cultural determinism

The myth of cultural determinism is the idea that the culture with which one identifies determines and therefore limits a person's abilities, chances for success, and "authentic fit" in careers and disciplines such as STEM. This notion can be used both overtly and covertly, as a means to limit educational opportunities and to structure available opportunities in restrictive ways. Worse yet, is when young students internalize cultural determinism, which results in a kind of cultural pessimism within the context of educational achievement. This internalization results in a 'self-fulfilling prophecy' that serves to limit this achievement, placing the study of certain academic subjects out of the reach of these students. For African American students, this often plays out as an aversion to academic achievement because peers would see such achievement as 'acting white' [22]. The phrase "keepin it real" is used in Black vernacular to reference the importance of cultural authenticity. Gender identity is also part of this complex system: sports and manual labor jobs for many black males is associated with "authentic" heterosexual, masculine identity, while white collar jobs have the opposite implication. [18]

The myth of genetic determinism

The myth of genetic determinism is the roundly debunked notion that one's genetic makeup, based on ancestral identity in the form of race, determines a persons' ability to succeed. Race has little genetic basis: our single human species left Africa a mere 60,000 years ago, and thus has not had time for significant evolutionary differentiation aside from minor changes in skin color, height, etc. Yet the concept continues to be used to classify and sort people: who are the most intelligent, most spiritual, and most human; which race is best, and which is worst. The ideas and definitions related to the terms of race and racism have evolved and changed overtime. They have been used to exert economic and political power of one group over another. [17]

The social construct of race

The social construct of race is not unique to the United States and has evolved and been redefined over time, but generally it is used to sort and classify people by biological differences between people. These biological traits can include skin color, hair texture, and body structure. The idea of race as a cultural construct that people use to define themselves apart from others, serves to construct and maintain class and power structures at both the individual and societal level. The cultural system of race allows dominant groups to use racial classifications to identify, label, and oppress others for their own individual or group benefit. [6]

Although physical traits are inherited, there is no common set of traits particular to any one race. In fact, there is a as much variation between individuals of a race, as there is between different racial groups. [25] Differences between people are the result of their environment and biological adaptation over time. Still, one's race is an important feature of one's identity and "continue[s] to be among the most significant social fact of people's lives". [6]

The control structure that is race leads to the disparate treatment of people of different races, which we refer to as racism. Racism also has a dynamic definition, depending upon which point of view we are considering, and from which historical perspective. Not surprisingly, different groups define the term racism differently, determined by their experiences. In the US racism is predominantly configured around conflict between whites and indigenous peoples (African and Indigenous American heritage), but that is not always true: for example “white trash” was created as a category of “genetically deficient” low-income whites with similar excuses around “preserving racial purity” [15]. Many people understand the term racism to be similar to “prejudice,” an individual’s ideas and feelings of dislike or hatred, but it is more accurately characterized as an institutional feature of society where the dominant group maintains a position of privilege and advantage over non-dominant groups. [6]

Institutionalized racism permits the maintenance of a system of privilege that is experienced by subordinate groups in many ways in their everyday lives. In the US this is often characterized as system of “white privilege,” and is especially evident in the values communicated to non-whites in the educational system. The experience for non-whites as they receive their education in schools indicates to them that what they perceive to be their group identity is inferior to others. Even in the case of “multicultural education,” typical examples in math or computing are geometry in Japanese origami, the Chinese abacus, and Vedic algebra from India. Since students with Asian heritage often out-perform whites, such examples do little to contradict the myths of biological and cultural determinism; on the contrary they reinforce them.

Race can be a predictor of IQ scores as well as the likelihood of academic success, however this is due to the social and economic consequences of race and not its genetic effects. In fact, a high IQ score is more accurately a predictor of the make and model car a parent drives than student ability. [20] IQ scores and intelligence testing in general is not a reliable measure of student ability, but rather a measure of the experiences their economic status in society has allowed them to purchase. For example, black IQ scores, have risen an average of 3 points per decade since 1930; they are now well above the white average from that era. [16] East Germans and West Germans are genetically indistinguishable, but their IQs were dramatically different until reunification. [31]

Just like cultural determinism, the results of genetic determinism are at their worst when young students internalize these ideas, which again result in limiting academic interest and desire for achievement, placing certain academic subjects out of reach. Expressions such as "I'm not good at math because I don't have the math gene", or "I'm not good at science because my parents aren't good at science", demonstrate how insidious these fallacies can be. All of these attitudes play directly into the social construct of race, which serves only to control and limit opportunity for those in oppressed ethnic groups.

The proposed study

I propose a mixed methods study that will look at the use of ethnocomputing, in the form of Culturally Situated Design Tools, to improve learning outcomes for underrepresented students. This study includes the process of interviewing indigenous artisans, designing tools based on their knowledge, the assessment of the tool in formal and informal learning, and the feedback process by which that assessment informs changes in the software design.

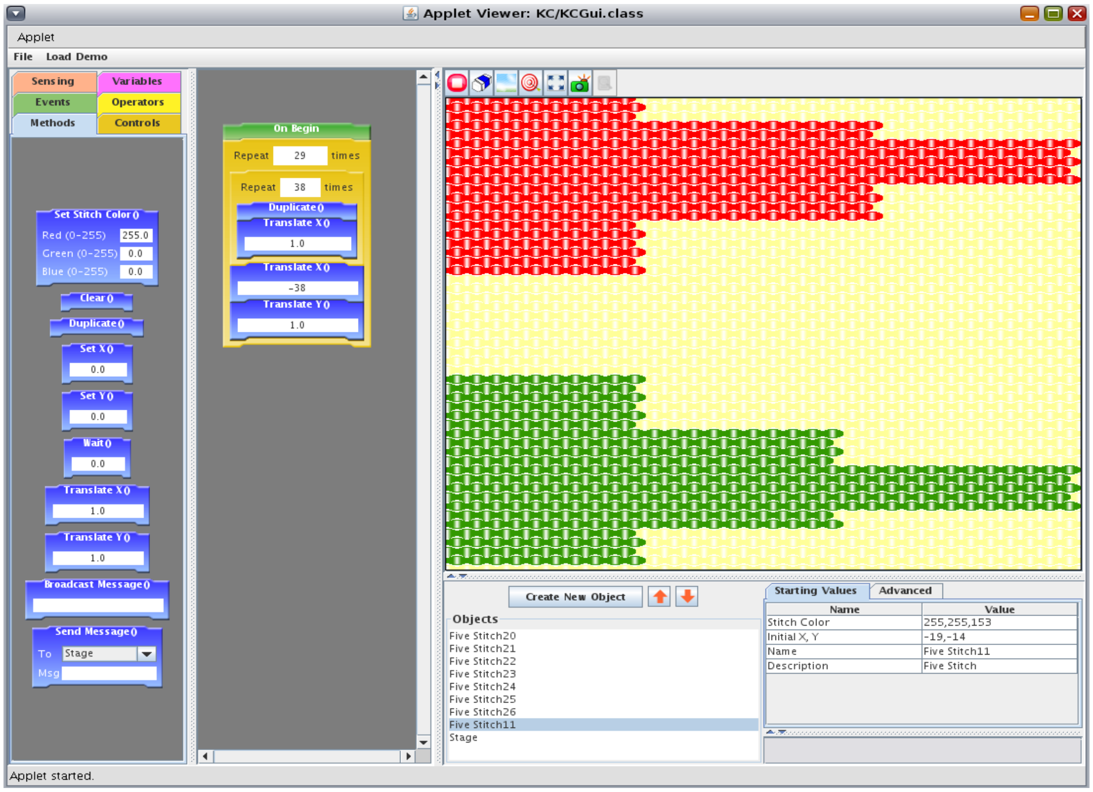


Figure 1
Kente Cloth programmable Culturally Situated Design Tool showing the Kente Cloth simulation program.

About programmable Culturally Situated Design Tools

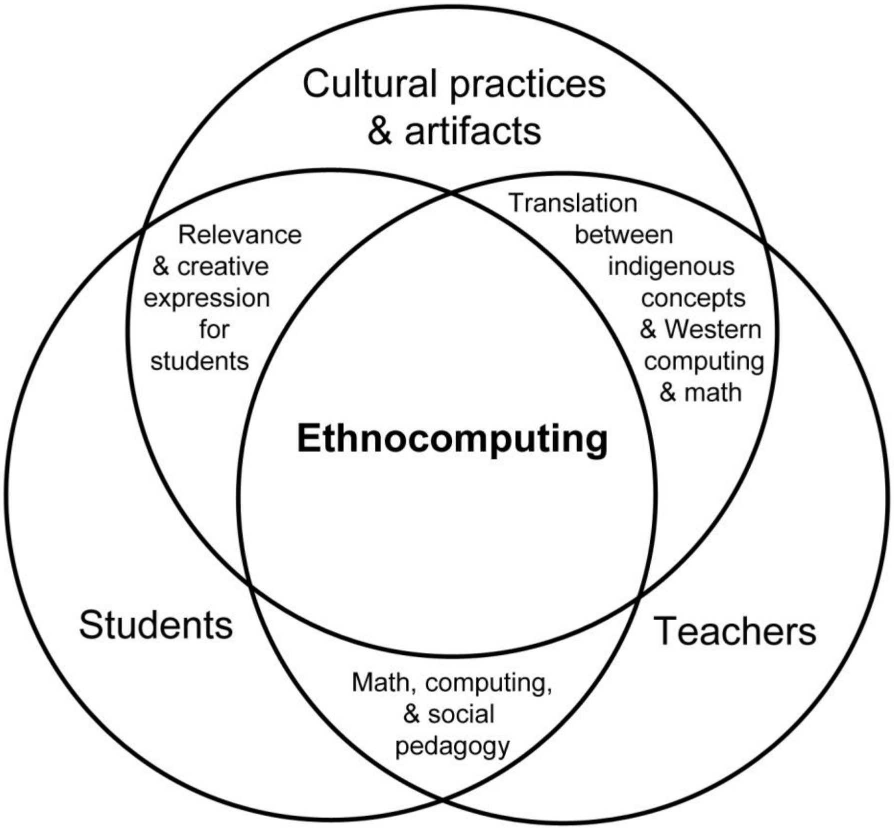
The Kente Cloth simulation user interface shown in Figure 1 is a programmable Culturally Situated Design Tool. The intent of pCSDT development is to teach mathematics and computer programming concepts through an indigenous craft in simulation. In this case, we are simulating the weaving of Kente cloth, which is a product of indigenous artisans in Ghana (located in West Africa).

Culturally Situated Design Tools (www.csdt.rpi.edu) were first proposed by Dr. Ron Eglash, and further developed by faculty members Mukkai Krishnamoorthy, Audrey Bennett, and several graduate and undergraduate students. The user interface pictured above shows the programming building blocks in blue (left most column), the scripting panel (middle column), and the output window on the right. The user assembles a program by dragging codelets from the left most panel into the middle scripting window; thinking computationally, the student arranges the codelets through trial and error experimentation; checking each time the script is run to see if the results are close to the desired design. Student learning occurs through this trial and error negotiation of the user interface as they construct a desired design output. This construction based learning has its roots in constructivist learning theory [24], which has evolved into Paperts constructionist theory. [23]

The applet toggles between a running state, in which the script is executed, and a ready state in which the user builds the script. Once the user puts the applet into the running state, this triggers the event queue to cycle through all of the system objects in the queue from front to back. This updates the system values for all of the object attributes affected by the codelets that have been added to the event 'On Begin' codelet in the scripting panel. The updates to values and any other changes to system parameters result in the alteration of the behaviors (typically graphical) that appear in the output portion of the user interface. For example, when the codelet titled 'Translate X()' is encountered in the scripting pane, it will take the value entered by the user in the text field and add it to the present system value of the 'x' coordinate. This will result in a horizontal shift, either positively or negatively in the objects graphical representation shown in the coordinate plane of the output window.

Software development

The development of the Culturally Situated Design Tools offers a rich opportunity to explore software development in the context of multiple and sometimes conflicting goals and user needs; it illustrates the difficulty of 'getting it right' in such circumstances. The pCSDTs offer this opportunity both through concept formulation and concept refinement, where the goals themselves can evolve as revisions reveal new aspects of user interactions. An analysis of the development process is thus relevant to scholars interested in the general process of software engineering, as well as specific areas such as educational software design and cross-cultural software design. It specifically offers an opportunity to look at software development in relation to the intersection of culture in the artifact to be simulated (both vernacular and ethnic heritage), the cultural identity of the user (both perceived and chosen), and the learning content (typically in reference to state or national standards).



Ethnocomputing is typically the search for an algorithmic basis to the construction of indigenous craftwork. These algorithms form the basis for what we refer to as cultural models in simulation. [15] Some examples of these simulations include model representations of Kente Cloth weaving and Adinkra stamping (also from Ghana), and the cornrow hairstyle of Africans, African Americans, and the Caribbean. Within the constructionist simulation environment, learning takes place in the construction of the artifact. This learning process has been referred to as authorship [23], or "design agency".[15] This search through the learning landscape involves the 'dance of agency,' in which the student encounters resistance in the learning process, and a gradual negotiation between their goals and the software behavior evolves towards a suitable compromise. [26]

The process by which these artisans create artifacts in the original setting is often based on a stepwise construction, which we can equate to steps in an algorithm. When we look carefully at the creation of these cultural artifacts we often find processes that follow in sequence, repetition and contingent execution based on the current status of the output. These ideas map directly to the computer science concepts of program flow of control, looping, and conditional statement execution. In simulations, these concepts form the building blocks of constructing cultural artifact representations through computer programming.

It should now be clear why it was necessary to carefully describe the problems of deterministic myths in holding back underrepresented students. If the goal is to make a case for why math and computing is a part of heritage, then the simulation cannot simply create the image of the artifact by any means; the simulation must reflect, at some level, the actual process used by the original artisans. At the same time, it cannot be too realistic: if we wanted to exactly recreate the original experience, we would simply provide a pile of beads, thread or whatever materials were used. It must work in a middle ground between pure symbolic abstraction and purely concrete materials. Its purpose is essentially to "translate" from the indigenous or vernacular knowledge to its equivalent in the contemporary classroom.

This brings us to the challenge of integrating learning as a goal. As a fundamental starting point, the work of Vygotsky is crucial. His 'zone of proximal development' (ZPD) greatly informs this work, providing a design target for the software.[32] The ZPD represents the point at which the level of difficulty is such that the student is sufficiently challenged in the problem-solving task through their own problem solving abilities, but not so frustrated that they lose motivation to continue. Moreover if the user is constantly learning, this implies that the ZPD must be constantly moving. Another term often associated with Vygotsky is "scaffolding" – like a building created with a temporary series of supports, a moving ZPD should allow the user to build on previous knowledge and skills to get to higher levels.

A good way to summarize this vision of a constantly moving ZPD is through Resnick's notion of "low floor and high ceiling" [30]. The low floor notion can be thought of as 'low barriers to entry', as in the software is very easy to start using, offering intuitive and uncomplicated means for a student to start working on a design. The high ceiling notion can be thought of as the software not limiting the student in the complexity of the design they wishes to create. Low initial learning curve and 'sky's the limit' software capability offers the student simulation software that can support a student's creativity, without placing limits on that creativity.

Mental Models in measuring success

How can we synthesize this complex interaction of different dimensions and levels into one over-all portrait? Here I will introduce the concept of "mental models," the idea that our mind can carry out cognitive tasks because it has models of "how things work"—whether that is shoelaces or software or symbolic equations. In particular I propose that by looking at indicators for changes in the students' mental models, we can better gauge student success and provide information for future refinements of the software.

An important question to explore is "How do we effectively measure the gain in knowledge, in this case a mix of mathematical and computer programming knowledge, which arises from the user's efforts in the artifact creation?" The starting point for this is the established methods of project portfolio analysis, artifact based interviews, and proposed design challenges. [9] I wish to extend these methods by adding a mental model representation to provide a framework for interpreting the results of these assessments in relation to the cognitive growth and development that the student experiences from their work with the software.

The assessment of K-12 computing education can be straight forward when it comes to vocabulary or other materials that can be tested on a multiple choice exam, but the knowledge gained through programming experience is not as easily determined. As Resnick states the problem, "there is little agreement about what computational thinking encompasses and even less agreement about strategies for assessing the development of computation thinking in young people". [9] One complication is that there may a series of incremental improvements, with a great deal learned despite never reaching the original goal. It will be important to capture these incremental successes in the natural order in which they occur, so as to track the development of computational thinking in students as they work to problem solve their way through the development of their designs.

In their work with the Scratch programming simulation environment, Resnick and Brennan have attempted to assess student learning through three different methods, 1) project portfolio analysis, 2) artifact-based interviews, and 3) proposed design challenges. [9] Project portfolio analysis attempts to measure the number of code blocks used in the creation of a student project, trying to get at the depth of exploration of the available code block tools offered in the Scratch programming environment. Artifact-based interviews involve talking with students about their Scratch project. Design challenges involve asking the student to select from a pre-determined list of tasks that have been designed to demonstrate the depth of their knowledge of programming in Scratch.

In working to assess the efficacy of teaching computing with the pCSDTs, an analysis method of student successes must be developed that accounts for the various nuances that indicate success. For that reason I propose a mixed method approach, one that includes both quantitative data and qualitative student observations and interviews, to improve this assessment. Again, following Resnick, it is important to develop a "computational thinking framework" to guide these assessments. [9] Thus I intend to guide this assessment--the project portfolio analysis, artifact-based interviews, and proposed design challenges of Brennan and Resnick -- using the concept of “mental model” as the over-arching framework.

Mental models are "conceptual organizations of information in memory" [28, p.45], that allow us to develop additional inferences about what we understand. [13] Mental models are not new, and have been studied and discussed quite extensively over the years. Disessa for example describes how physics students initially describe tossing a ball in the air as a process in which force from the hand is gradually overcome by force of gravity. [14] Eventually they learn that force from the hand only acts on the ball when the hand is in contact with it: they change their mental model. The understanding of the mental model representation is to help us imagine how we apply previously learned concepts to new, unfamiliar concepts, which result in extending our understanding. As such, mental models are "abstract descriptions of memory", which "we cannot directly observe;" they are also “dynamic representations that can change over time". [28, p.44] In this study, I propose the inference of user mental models from data to assess and analyze the significance of student-learning outcomes.

We know that mental models can be formulated using linguistic data. [11] In this case I propose that the mental model can be inferred by using pre and post-test data, student created artifacts and interview responses. In fact, each of the Brennan and Resnick assessments can be thought of as forming a piece of the mental model representation. Initial student mental models will then be compared to the students' mental model after working with the pCSDTs, which will be determined from post-test data, post intervention interviews, and analysis of the student created artifact. The differences found in the mental model would then be attributable to the learning activity using the pCSDT ethnocomputing software.

Exploration of culture, cultural identity, and cognition

Also to be included in this mixed methods study is a qualitative exploration of the intersection of culture, identity, and cognition.

Constructionist learning software such as the Scratch programming system teach programming in a 'content agnostic' fashion, meaning that no guidance is provided to the student in what the topic will be or what elements contribute to it. This approach leaves the entire process entirely up to the student, which looking at the results posted to the Scratch website, means that an overwhelming amount of time, the project outcome looks akin to some consumer culture creation, which is as likely as not to reflect some sort of first person shooter game or a corporate-created toy or movie.

Upon reflection, it is easy to see why this happens. Students live in a media and consumption-saturated world. These experiences are most likely linked to their immediate environment, which would be highly influenced by whatever is currently on television or other commercial media or other form of consumption. The universe of available experiences thus narrows sharply for these students, and most likely will center on the current, highly marketed item, be it entertainment or fashion or junk food. The argument for Scratch is that “students become media producers, not media consumers” but this is contradicted by the content. In fact, Ito explains Papert's view of constructionism as one in which the content, or what is being produced, is always a secondary consideration, with "technological fluency" being of primary importance.[12, 143] This view seems flat to me, considering that a deeper understanding of content from non-commercial sources can open up all manner of areas for further exploration. Such areas include history and art, which have the potential to be so much more rich and rewarding.

The Culturally Situated Design Tools represent constructionist-learning software in the flexible, open-ended style of Scratch, but with the added benefit of rich and rewarding content in simulation. For example, using the Cornrow Curves software offers the opportunity to learn the geometry and algorithmic process embedded in cornrow hairstyles, while simultaneously teaching elementary programming concepts. In addition, and equally important, this particular tool offers the opportunity to explore the history of the cornrows hairstyle, which underscores the fact that this is essentially a geometric practice deeply rooted in both African and African American culture. This offers an opportunity to return to underrepresented students that which is rightfully theirs, a sense of math and computing as part of their heritage. It is providing an experience that shows that there is math and computational thinking underlying something that they have encountered - and that they own. Multicultural education has successfully entered the curriculum in humanities, but underrepresented students, and in particular African Americans, encounter math as a subject still anchored in the names of Pythagoras, Descartes and other Europeans. Math is stripped of any application beyond rudimentary word problems which do little to offer a connection to their own experiences.

Framing math and computer science as culturally situated activities returns to these students what has been stripped away. This is especially rewarding for me when we look at this process through Bourdieu's Cultural Capital. Bourdieu points out that a students' culture imparts to them some advantages, frequently from parents who look to improve their children's lives with the benefit of what they themselves have learned.[8] The difficulty for underrepresented students, with only a small number of exceptions, is that their parents did not successfully navigate the public school system, and yet these parents are responsible for seeing that their children accomplish what they did not. In the privileged world, this is not the case, where parents provide an enormous amount of guidance, purchasing for their children all of the requisite experiences they need to have along with the knowledge that comes with them, in particular those that are most beneficial and helpful to academic success. Privileged children are thus less likely to be negatively impacted by the consumerist content in a system like Scratch; they have a sense of ownership over other things like academic activities. The Culturally Situated Design Tools can be seen as helping to provide underrepresented students with an understanding of how their cultural capital has value in the academic world. This value may never see the light of day if they are restricted to the 'content agnostic' approach.

From a research point of view, this 'content agnostic' versus 'content guided' contrast offers a rich area for exploration. When we consider computational thinking, which is what we're getting at with this type of constructionist learning, and its intersection with cultural thinking, the ways in which a particular aspect of a cultural practice is framed by the simulation may affect concepts of cultural identity. Do all African American children identify with the cornrows hairstyle, or does this vary depending on other factors (for example Caribbean heritage vs. Southern Heritage vs. recent African immigrants)? Do they all find an attachment to the mathematical and computational aspects of the simulation, or does that vary with the degree of identification or other factors (for example one may be close by heritage but distant in terms of personal experience, aesthetic preference, etc.)? What other motivations and reactions are at work as students encounter these cultural simulations?

In my initial work with students at Hackett Middle School (Albany, NY, Urban) I found that this correlation is not necessarily straightforward. One African American female student was just giddy with the idea that someone took the time to develop software that simulated her cornrows hairstyle. Another African American female did not consider the Cornrow Curves pCSDT terribly exciting (though interestingly enough, she had a cornrow hair style). This student however, thoroughly enjoyed the time she spent working with the Navajo Rug Weaver pCSDT application. These two examples suggest one case in which there was a strong correlation between cultural identity and interest in the corresponding pCSDT tool, and conversely another case in which the stronger interest was in a tool that does not correspond to the users' cultural identity (a "disidentification" so to speak that could not be explained by distance from the practice itself, since it was sitting on her head as she worked).

The planned research will look at this correlation to try to understand cultural identity and a students' choice of pCSDT tool. This intersection between cultural identity and subsequent choice of tool indicates an "interest driver" that will yield information about how much it matters to a student, and how strongly cultural identity corresponds with motivating interests. This intersection is likely to be most interesting when there is a mismatch between a student's cultural identity and the pCSDT tool of choice. Additionally, this intersection will help to shed light on student thinking when a tool designed to create one type of artifact is used to create something entirely different. For example, students working with the Navajo Rug Weaver tool have used it to create a Jamaican flag design as their final project in working with that tool.

How can we use the information gained from studying this intersection? The applications of this information range from theoretical concerns—how cultural identity matters in theory of learning—to practical considerations in the future deployment of this tool (for example helping guide the development of lesson plans). Of particular interest for this study is the use of this data to continue to refine the design of this software, making it more user-friendly and effective as a learning tool. These practical outcomes can also contribute to scholarly research with further analysis. This is not a trivial outcome as enormous amounts of time is spent in teasing out development decisions that result in tools that are easier for a student to use, that are more stable and thus reduce student frustration.

In addition to tool design, exploring how students use culture and identify (or not identify) with it is likely to yield interesting results that we just cannot predict. We know that children do use culture, whether it is their culture of heritage or a self-chosen vernacular culture. Children's identities easily involve their associations with different cultures, even if it is something as shallow as consumer culture. The interesting aspect of this research will be to see if their use of culture will be as we assumed it to be, or if it ends up being something more complicated or completely different. Likely, there will be lots of permutations in student associations, student heritage, and popular culture, which will result in interesting outcomes.

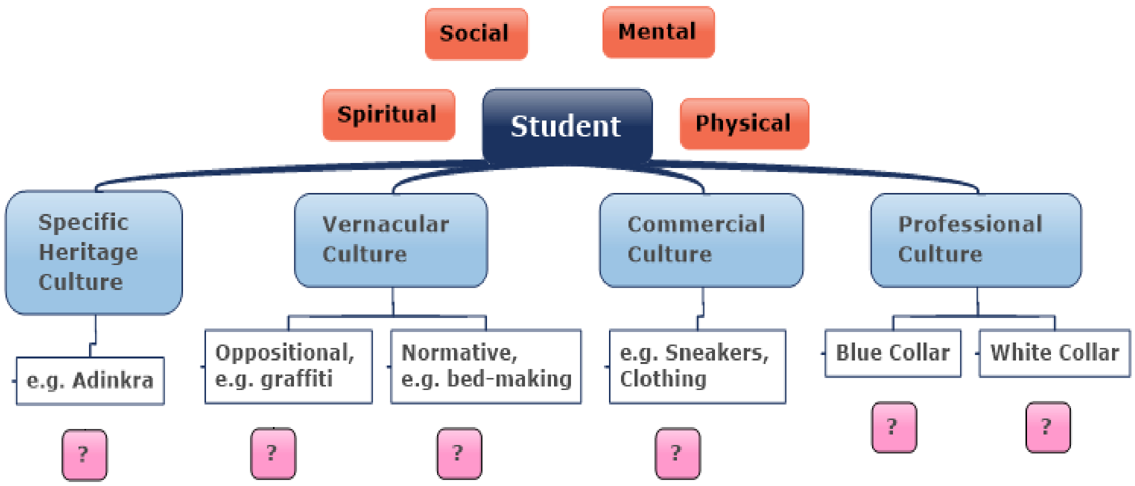


Figure 2.
Culture and student identity.

Cultural identity and how it matters

In Figure 2, we can see the many forces at work in determining identity and how a student thinks about how they fit in to the different cultures around them. This list is by no means exhaustive, but it should provide a general sense of some of the categories we can consider. The diagram begins at the most general level with the Spiritual, Physical, Social, and Mental experiences that a student may experience. These forces push and pull the student as they negotiate their way through the process of constructing an identity. The cultures that people will experience include their Heritage Culture (that of their parents), everyday Vernacular Culture, the ubiquitous Commercial Culture, and nearby adults' Professional Culture. Each of these cultures may have varying impact on the student. Each may be multiple – more than one heritage, profession etc. is almost certain to be present for most children. The exciting questions are "Do they matter?", "How do they matter?", and most importantly, "Can we find a way to help them contribute to improving student academic achievement?"

Anticipated contribution to science

The mixed methods study outlined in this proposal extends important work undertaken by other professionals in the fields of technologically mediated education. The development of a mental model method for evaluating student projects in constructionist simulation software extends important work by Brennan and Resnick for use with MITs Scratch programming environment. The qualitative study of culture, identity, and cognition continues important work undertaken by Eglash, Bennett and Krishnamoorthy in their work with the Culturally Situated Design Tools. The CSDTs were the non-programmable precursor applets to the programmable CSDTs discussed in this document. The combined studies outlined here will help to further our understanding of the achievement gap in underrepresented students in Science, Technology, Engineering, and Mathematics; and might possibly succeed in offering ethnocomputing as a means to combat this debilitating trend.

Schedule

The proposed study outlined in this dissertation proposal is a continuation as well as an expansion of ongoing research, both at Hackett Middle School in Albany New York as well as the Ayeduase School in Ghana West Africa.

Definition and Scoping

April 2013 – Nominate Dissertation Committee

June 2013 – Submit Candidacy Proposal

September 2013 – Complete Candidacy Exam

Data Collection

July 2011 – Gathered Data from Ayeduase Students, Ghana West Africa.

July 2012 – Gathered Data from Ayeduase Students, Kente Weavers, and Adinkra Crafts people Ghana West Africa.

School year 2010-2011, Gathered Data from Hackett Middle School Students as part of GK-12 NSF grant.

School year 2011-2012, Gathered Data from Hackett Middle School Students as part of GK-12 NSF grant.

July 2013 – Gather Data from Ayeduase and Ntonso Students, Ghana West Africa (Identity and Cognition).

September and October 2013 – Gather Data from Hackett Middle School Students (Identity and Cognition).

Results and Analysis

January 2014 – Review findings with Dissertation Committee

Spring 2014 – Complete written Dissertation document for defense by May, with graduation in August 2014.

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