

# Updated AADMLSS: Design and Evaluation of a Culturally Relevant Algebra Application

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## Abstract

Algebra I students often feel learning and practicing algebraic concepts is an extremely boring task. Current online software exists to help make learning more engaging, however students have reported dislike of several of its available features. Difficult explanations, negative reinforcement, as a result of utilizing hints, and lack of customization and interactivity are factors that contribute to their disdain. Researchers at the University of Florida created a culturally relevant web-based application to assist in the engaging of minority Algebra I students. Their alternate approach to resolving students' issues include providing: a three-part system that infuses the students culture into their lesson, an interactive way to practice learned information and informative and action-specific help and feedback. This application takes a culturally relevant approach and uses hip-hop music, cartoon or comic-like imagery, and a *game-like* environment to teach algebra. Results from the study indicate, although the system did not improve performance on administered pre and post quizzes, students preferred the new system to current software.

## Keywords

Algebra, Culturally Relevant, STEM Education, K-12, Hip Hop, Educational Technology

## 1. Introduction

Success in mathematics education among African American students is an epidemic crisis. Studies by reputable organizations, such as The National Assessment of Educational Progress (2015), report the pervasive underachievement of African American and Hispanic students in comparison to their White counterparts <sup>1</sup>. The design of innovative pedagogies that utilize culture, is one suggested way to combat this disparity <sup>2</sup>.

## 2. Carnegie Learning

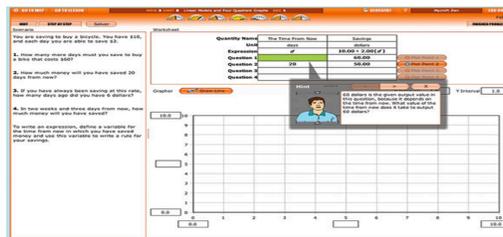


Figure 1 Carnegie Learning Interface Design

Carnegie Learning, developed by computer scientists at Carnegie Mellon University, is most heavily used within a high school's Algebra department in Gainesville, FL. Each week, students

are assigned a unit to complete. Each unit contains varying numbers of lessons, broken down into sections along with worked-out examples and a section to test their understanding before completing a step-by-step problem. Upon reaching the final section, students are given similar problems to fully test their comprehension; this section provides limited hints by one of three selected avatars.

During a focus group, Algebra students provided negative reviews of the current interface, seen in Figure 1 above. The interface proved disengaging with mediocre problem formats and ineffective software designed to reinforce concepts taught in class. The students also stated dislike of Carnegie Learning's "boring" visual aesthetics which consists of screens with bland colors and backgrounds mimicking white graph and lined paper; the dull interface does little to hold the students' attention. When asked to design their own way of making a more exciting way to learn Algebra, they desired an interactive game, which sharply contrasts their current interface. The focus group preferred a more visually pleasing interface with vivid colors and the possible incorporation of music. The quality of the hints the system offered were rated unsatisfactory and insufficient - ineffectively leading to the correction of an incorrect answer. After a limited number of hint requests, the system generates the correct answer, allowing users to continue moving through lessons without full comprehension of the subject matter. Although culturally diverse, the students expressed dissatisfaction with the lack of variety in choosing the characters that assisted with hints and preferred more freedom to construct their own characters.

### 3. Related Works

Kebritchi, M., Hirumi, A., & Bai, H sought to study the effects of computer-based math games on students' achievement and motivation. Pre-Algebra and Algebra students and teachers were randomly assigned to experimental and control groups for 18 weeks. The experimental group played a set of interactive math games, called DimensionM, for 30 minutes per week outside of normal instruction time. Motivation surveys and district-wide benchmark tests collected data that showed the games significantly affected the achievement rate of students. While the calculated results say the students' motivation remained at baseline, the interviews conducted with students and teachers showed otherwise. The researchers attributed this discrepancy to the possibility that the teachers in the control group tried to make math more exciting during the experiment and/or the students did not associate the game with their class<sup>3</sup>.

Offer, J., and Bos, B. examined the effectiveness and design of technology based courses (TBCs) in math classrooms. 139 eighth, ninth, and tenth graders utilized the TBC as a supplement to normal instruction. The TBC featured virtual characters that solved real world problems given to their math club by the community. The TBC is comprised of units that begin with an overall problem, followed by pre-tests, tutorials, guided practice and graded assignments. The integration of real world problems helped with motivation and conceptual learning for the students. The teachers found the self-graded assessments beneficial to the learning process and the computer-graded assessments as mirrors of the standardized tests. The students had issues with the difficulty level and limited time to complete both assessments<sup>4</sup>.

Kaloo and Mohan examined the use of games for learning Algebra through a student survey on gaming and mobile phone use, and a MobileMath learning study. The mobile learning study,

conducted in Trinidad and Tobago, provided evidence that games are helpful to students and preferred for learning mathematics. 60 students, divided into 3 groups, used a mobile application for three weeks to learn algebra. The MobileMath application offered several learning activities such as text-based lessons, dynamic examples, quizzes, tutorials and games. 68% of the students agreed they preferred the games over the other features offered. The researchers identified several important aspects of the game: rewards, challenges, visual appeal, engagement, interactivity, feedback, animations and reinforcement learning. This evidence suggests in the creation of any algebraic games, these aspects must be included in order to increase the chances of success <sup>5</sup>.

Davis et. al state Hip Hop in Black Education (HHBE) for African American students in mathematics should be approached from 5 areas of caution. The first is that rapping, using rap text, or sharing rap videos in mathematics classrooms without any critical examination of rap music, the artist lifestyle, or the communities they rap about is not liberating. The second is practitioners' lack of understanding of what does and does not constitute HHBE practices. Third is the development of African American students' racial, cultural, and mathematics identities. The fourth caution is to understand how social constructions of race, racism, and other forms of oppression impact African American students' mathematical experiences and lived realities. Lastly, there has been a paradigm shift in mathematics education to focus on successful or high-achieving African American students <sup>6</sup>.

Gilbert et. al defined culture as “who we are and what we do”; summarizing it as a combination of age, race, ethnicity and gender along with religion, likes and dislikes. Building on research that suggests using student’s cultural knowledge can positively impact learning, Gilbert and his colleagues developed the African-American Distributed Multiple Learning Styles Systems (AADMLSS), an application that teaches algebra to urban African-American students. AADMLSS uses hip-hop music, colorful illustrations, realistic situations, African-American characters and a game-like environment to help students relate to the material being taught. A study conducted at a Chicago school found the students enjoyed using the application and the math related rap lyrics easy to remember. Although using AADMLSS helped students become more engaged, Gilbert and his colleagues did not find any learning effects <sup>7</sup>.

#### 4. AADMLSSv2 System Design



Figure 2 Interface Design

AADMLSSv2’s approach to solving students’ issues included providing them with a system that infused their culture into the lesson in an interactive way, giving informative and action specific help and feedback. The interface is a web based application with which students are able to learn, practice and test their knowledge of basic algebra concepts using relatable examples. Previous

literature states interactive technology has been able to teach students while keeping them motivated and engaged.

The interface contains three separate sections: Video Lesson, Interactive Lesson and Guided Practice, shown respectively in Figure 2 above. The Video Lesson section of this interface uses an application called AADMLSS City Stroll (<http://www.aadmlss.org/>), created by members of a research group called the Human Experience Research (formally Human-Centered Computing) Lab. This application takes a culturally relevant approach and uses hip-hop music, cartoon or comic-like imagery and a *game-like* environment to teach algebra. This specific culturally relevant tool was included because the focus group included mostly African-American students who all enjoy music and games.

The Interactive Lesson section, one of the two novel portions of the application, presents an algebra problem similar to the problem presented in the video lesson. Students use direct manipulation, drag and drop among other methods, to make real life decisions to solve the appropriate equation, step-by-step.

During Guided Practice, the second novel contribution, students are able to practice working out a problem on the current concept on their own. They have the option to receive hints or guidance from the avatar they chose upon creating their account. After a certain number of hints or inactivity, the guided avatar walks through each step of the problem while the steps are also shown visually on the page.

## **5. Study Design**

### **5.1 Participants**

Participants were high school students who had completed or were currently taking a high school level Algebra 1 course. Students who met the qualifications for participation were recruited by the principal of their high school and their current or former Algebra 1 teachers via in class or intercom announcements.

### **5.2 Participant Procedures**

Before the study, all potential participants in our population pool were given a parental consent form to take home; only student who returned a signed consent form were eligible to participate. Each participant was seated at a computer, read the assent form and asked if they were willing to participate.

If the student agreed, he or she was given an online pre-assessment. This pre-assessment collected data on the participant's gender, ethnicity, age, and grade level. Data on their current Algebra learning technology, Carnegie Learning, frequency of practice outside of the Algebra classroom, and issues they have with the current way they are being taught Algebra concepts were also obtained. Upon completion of the assessment, the students were directed to the AADMLSSv2 login page and prompted to create an account and login. The student was allowed to choose a unique username, password and one of six avatars. The avatar selected was used in the Interactive Lesson and Guided Practice to offer auditory assistance to the student and could be changed at anytime while logged in.

Once the student logged in, he or she was instructed to begin an Algebra 1 lesson. Each lesson began with a short math pre-quiz. The purpose of the pre-quiz was to gauge the student’s prior knowledge of the current concept. The pre-quiz was followed by a video lesson that incorporated music, rap lyrics, and animation. Next, students utilized an interactive lesson, based on the scenario in the video. Students were then taken to a guided practice page. At the end of the guided practice, the students were given a post-quiz. The post-quiz was in a similar structure as the pre-quiz and designed to assess learning gain on the concept being taught. Lastly, the students were given a post-assessment. The post assessment obtained data on the students’ satisfaction as well as the usability of the system.

**5.3 Metrics**

There were two types of metrics used in this study: objective and subjective. The objective measurements were obtained from data recorded in the system. Before the participant began the Algebra 1 lesson, they were given a pre-quiz made up of five Algebra 1 questions related to the content taught in the lesson. The pre-quiz score was calculated by counting the number of questions answered correctly. After successfully going through the lessons and guided practice, students were presented with a different quiz, also composed of five Algebra 1 questions directly related to the material covered by the lesson.

The subjective measurements were acquired through questionnaires. The website preference metric was collected via a survey question that asked: “Would you prefer to use the new website instead of Carnegie Learning?” The response to this question was either “yes” or “no”. The likelihood of use metric was collected via a post-survey question that asked “On a scale from 0-10, how likely are you to use the new website to practice Algebra?”. The response to this question is a whole number value that ranges from 0 (Not at all likely) to 10 (Extremely likely).

**6. Analysis and Discussion**

There were twenty-three 9th and 10th grade students recruited by their math teacher. Before and after students interacted with AADMLSSv2, participants completed a pre and post survey, respectively. Out of 23 total participants, only 22 completed both surveys. Data was discarded of the one participant who only completed the post survey. On the post test, also participants were specifically asked if they would prefer AADMLSSv2 to the current system, Carnegie Learning and asked to respond Yes or No.

# of Successes (yes)	# of Failures (No)	# of Trials	p-value	Significance Level ( $\alpha$ )
17	5	22	0.00845	0.05

*Table 1 Exact Binomial (Sign) Test*

The researchers hypothesized that the participants would prefer using the AADMLSSv2 interface over Carnegie Learning. To test this hypothesis, an Exact Binomial (Sign) Test was conducted, seen in Table 1 above. This test assumes the probability of a success is 50%, or 0.50. In this study’s case, a success is a “Yes” response to the question “Would you prefer to use the new website instead of Carnegie Learning?”. Based on the assumed probability, the team would

expect 11 successes which would indicate people preferred the new system just as much as they did the current system. The Exact Binomial (Sign) test determines the likelihood the observed success rate (0.77) is in the same population as the assumed success rate. A p-value of 0.00845 means there is less than a 1% probability that we would see 17 out of 22 successes in a situation where there is a 50% chance of success. With this information, it can be inferred this large success did not occur by chance; the participants really, did prefer AADMLSSv2 to Carnegie Learning.

Before and after students interacted with the main components of AADMLSSv2 (Video Lesson, Interactive Lesson, and Guided Practice), participants completed a pre and post quiz, respectively. Out of 23 total participants, only 15 completed both quizzes. Data of the participants who only successfully submitted one quiz was discarded.

	n	$\bar{x}$	s	Standard Error of Mean
Pre-Quiz	15	68	25.96701	6.70465
Post-Quiz	15	69.33	30.11091	7.7746
Mean <sub>pre</sub> - Mean <sub>post</sub>	15	-1.33	33.4	

t	df	t <sub>critical value</sub>	p-value	
0.05	-0.15	14	2.145	0.441452

Table 2 Paired Sample t-Test

To compare the different scores, a paired sample t-test, seen in Table 2 above was conducted. This test was conducted to assess whether participants scored higher on the post-quiz than the pre-quiz after interacting with AADMLSSv2. The results of the paired sample t-test suggest participants will not score higher on the post quiz after interaction with the developed system.

### 7. Conclusions and Future Work

After using AADMLSSv2, high school Algebra I students showed a preference for this system over Carnegie Learning, the system currently being used in their classrooms. Anecdotal evidence (student comments as they spoke to one another) suggests student preference was impacted by the inclusion of hip-hop music and the cartoon or game-like interface. However, the researchers intend to conduct further studies to confirm this data as current results did not show any learning gains despite student enjoyment. It is believed limited exposure and network difficulties played a part in this result. In the future, the researchers plan to conduct a longer-term study where students receive multiple lessons using AADMLSSv2. The high schools, school boards, and University technical staff will be worked with to ensure Internet access and bandwidth via the school’s network or a robust network that the researchers will provide themselves. Although the results of this research were inconclusive, researchers believe AADMLSSv2 has the potential to be an impactful learning and motivational Algebra I tool.

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