Culturally Situated Design Tools: Animated Support Tools for Mathematics

Albanie T. Bolton[1,2] and Cheryl D. Seals[1,3]

[1] Auburn University, Auburn, AL 36849
[2] 741 Plummer Rd. #408, Huntsville, AL 35806
[3] Shelby Center for Engineering Technology, Suite 3101M, Auburn, AL 36849
{atb0010,sealscd}@auburn.edu

Abstract. Culturally Situated Design Tools (CSDTs) are web-based software applications that allow students to create simulations of cultural arts: Native American beadwork, African American cornrow hairstyles, urban graffiti, and so forth; using these underlying mathematical principles. CSDTs are the rationale of creating a set of culturally designed games utilizes gaming as a teaching tool to attract and instruct students with familiar methods and environments. The focus of this study is on Ron Eglash and others research on the indigenous design of various cultures using computer game simulations to teach math and computer science in the classroom sector. This study will review the development and evaluation of CSDTs, and discuss how various activities attempt to navigate through the potential dangers and rewards of this potent hybrid of information technology (CSDTs), traditional culture and individual creativity.

Keywords: Culturally Situated Design Tools (CSDTs), educational gaming, ethnomathematics, mathematics, culture, computing.

1 Introduction

Diversity does not refer only to ethnicity or race. [It refers to] differences in social class, family culture, geographic, religious backgrounds, and learning styles which are all reflected in our classrooms as important components of diversity [2]. Culturally responsive instruction addresses the specific interests, concerns, and experiences of students in the classroom. Therefore, teaching math and computer science in culturally responsive ways means using students' own habits, experiences, and cultural references to connect to real-world experiences with numbers, shapes, patterns, chance, and measurement. Successful methods for learning, calculating, memorizing and communicating about math actually differ quite a lot across cultures. This is where the term Culturally Situated Design Tools come into play.

Culturally Situated Design Tools allow students and teachers to explore mathematics and computer science with depth and care, using cultural artifacts from specific times, places, and cultures. Ethnomathematics is the study of mathematical ideas and practices situated in their cultural context. The Culturally Situated Design Tools website provides free standards-based lessons and interactive "applets" that help students and teachers explore the mathematics and knowledge systems using

M. Kurosu (Ed.): Human Centered Design, HCII 2011, LNCS 6776, pp. 351–359, 2011.

ethnomathematics in areas such as African, African American, Youth Subculture, Native American, and Latino. The supporting materials for the CSDTs include lesson plans and evaluation instruments to ensure they are integrated into the curriculum through state and national standards. Based in K-12 schools with significant numbers of African-American, Latino, and Native American students (current locations include Alaska, California, Idaho, Illinois, Michigan, New York, and Utah), preliminary evaluations indicate statistically significant increase in both math achievement and attitudes toward technology-based careers.

The CSDT simulation software and teaching materials are copyrighted to Ron Eglash and Rensselaer Polytechnic Institute. The software is provided on the web by Dr. Ron Eglash at *http://www.rpi.edu/~eglash/csdt.html* [3], a professor at Rensselaer Polytechnic Institute and the author of *African Fractals: Modern Computing and Indigenous Design*. When instructors have a sense of what issues motivate and are interesting to their students they may want to search various ways to teach more culturally effective. Using this site is a very effective way of doing this. Although the use of mathematics and computing is universal, math is not culturally neutral. This is why there is research being done on how to incorporate math and computer science into gaming.

Ron Eglash sees that there is not enough diversity in these fields and what can individuals do to get the attention of students into these areas. Therefore, he constructed these tools on the basis of researching in the areas of ethnomathematics, mathematics, computing, and educational gaming. The sole inspiration of this project is based on Dr. Ron Eglash's research.

The project we focused on out of the CSDT Series is the Break Dancer tool (Figure 1), located on the CSDT website. The Break Dancer tool is a software-simulated game that teaches 3-dimensional space or solid geometry. Real-world objects exist in 3-dimensions. For example, a cuboid, or a box, is described by three parameters, length, breadth, and height. Corresponding to that, each point in the Cartesian space has three coordinates - x, y, and z [1]. In this project, the Break Dancer tool integrates the youth subculture, promotes physical activity, and makes it into an educational game.

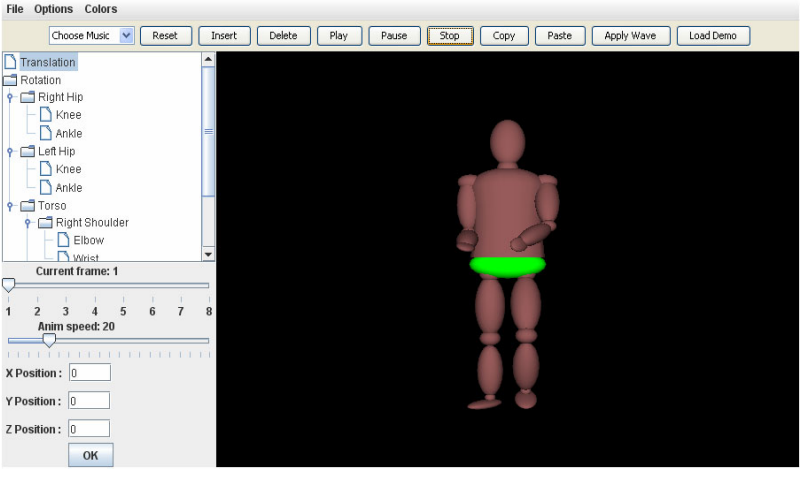

Fig. 1. Break Dancer Tool GUI

The project aims to provide a source for increasing teaching aide in schools. In addition, develop a gaming convention that will hold the student's attention in the field of mathematics. This field scares most students and keeps them away from Computing and IT jobs because this is required in the coursework. If we can help instill in students that math can be fun and innovative, this will bring more high school graduates entering college with a higher confidence level in math.

2 Using CSDTs as Teaching Aids

Ways of saying games reflect a cultural value is that games are social contexts for cultural learning. This means that games are one place where the values of a society are embodied and passed on. Although games clearly do reflect cultural values and ideologies, they do not merely play a passive role. Games also help to instill or fortify a culture's values system. Seeing games as social contexts for cultural learning acknowledges how games replicate, reproduce, and sometimes transform cultural beliefs and principles. This way of looking at games forms the basis of this schema Games as Cultural Rhetoric [6]**.**

Games contribute to the development of knowledge by having a positive effect on the atmosphere in the class which produces a better mental attitude towards math in the pupils. Educational games provide a unique opportunity for integrating the cognitive, affective and social aspects of learning [3]. Each CSDT topic comprises a number of resources that enable teachers to integrate the topics into standards-based math instruction. Resources for each topic include:

1. A section on cultural background and history
2. A tutorial on the math topic and its connection to cultural artifacts and systems of knowledge
3. Software (applets) that enable teachers and students to simulate the development of these artifacts
4. Links to extensive teaching materials—including lesson plans, pre- and post-tests, and samples of student work from a wide variety instructional settings.

Many game features, combined and designed effectively into educational gaming, could teach many things in an engaging and motivating manner. Games could be used for the expansion of cognitive abilities, as well as a platform for developing new or practicing existing skills in the context of real world goals, rules, and situations. Games could also be used to teach old subjects in new ways.

There are skills that are hypothesized to help with the use of games and simulations: higher order skills, practical skills training, high performance situations, rarely used skills, developing expertise and team building.

3 Break Dancer Tutorial Development

The tutorial development was done to improve the current tutorial at hand. The current tutorial (Figure 2) needed more information added to get a better understanding for what was being taught.

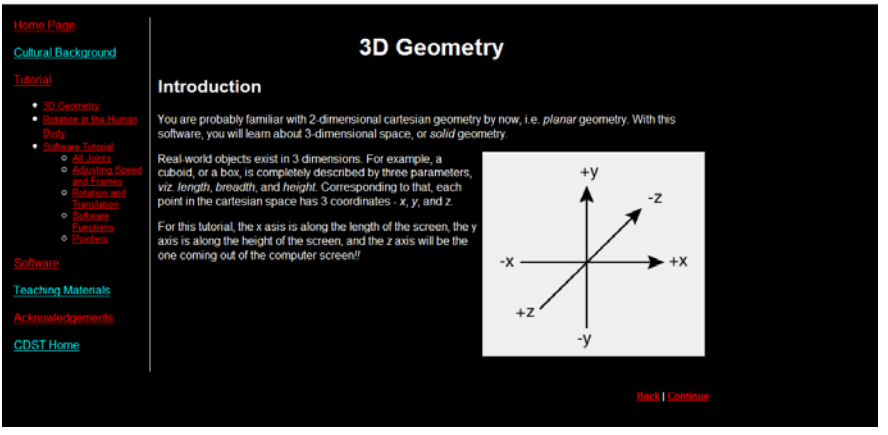

Fig. 2. Online Break Dancer Tutorial

The current tutorial is in the following outline:

- 3D Geometry
- Rotation in the human body
- Software Tutorial
    - All Joints
    - Adjusting Speeds and Frames
    - Rotation and Translation
    - Software Functions
    - Pointers

In doing the revised tutorial, we did extensive research on the Break Dancer tool and we contacted math teachers to get an understanding of what would be needed to compile a lesson plan. The previous version of Break Dancer's tutorial only highlighted a few of the topics that were discussed in the tutorial.

In the new tutorial, we talked about every topic in extensive detail, also including examples with each explanation (Figure 3).

The revised tutorial outline was changed to the following:

- Introduction to 3D Geometry & Space
- Tait-Bryan Angles
- Cartesian Coordinates in 3D Space
- Transformations (Translations & Rotations)
- Sine Function

The revised lesson plans should be equally if not more beneficial to the students and the teachers. The tool we used to design the new tutorial is PowerPoint and Captivate. We also created lessons plans and mini tests. We did data analysis on the tutorial, lesson plans and mini tests. The results are expressed in the next section.

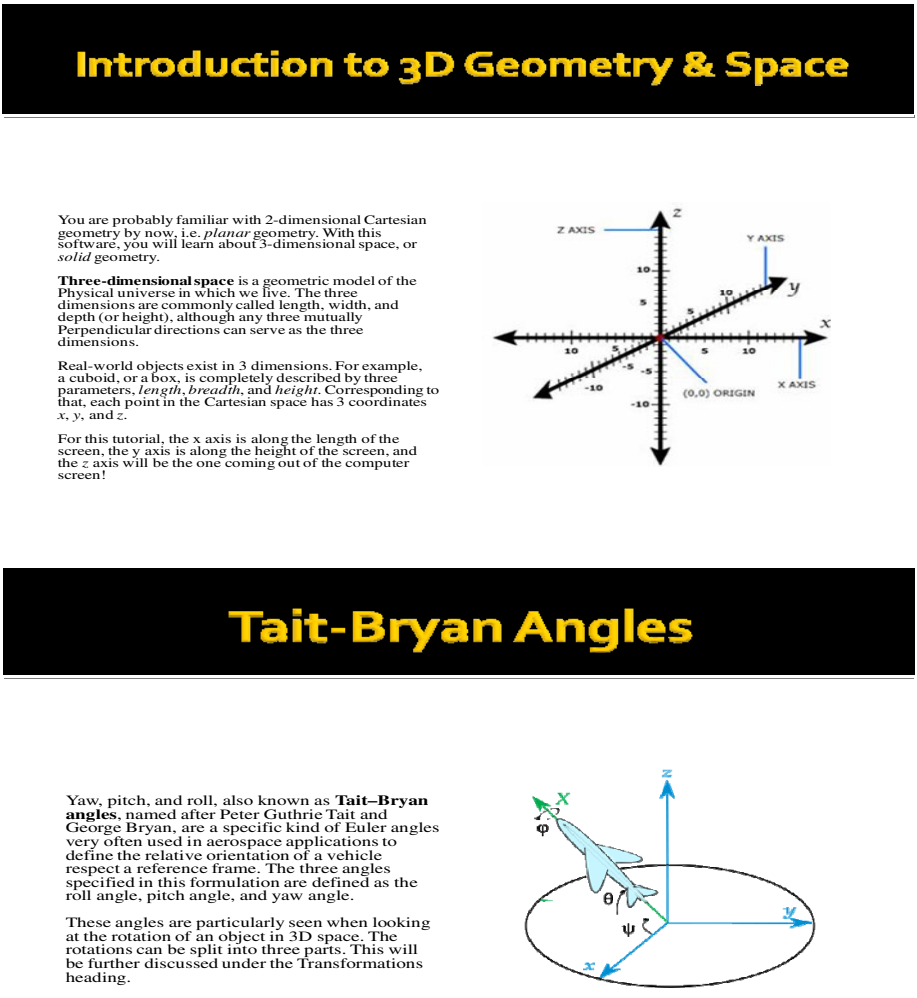

Fig. 3. Revised Break Dancer Tutorial

4 Data Analysis

4.1 Data from the Usability Testing of Tutorial

The questionnaire used for the testing of the tutorial contained four questions that focused on the teachability and learnability.

There were ten participants who were teachers and not previously exposed to the CSDTs. For most cases, we would normally have about 30 participants for a full analysis. Due to the response level, we went with an approach of opportunistic sampling. It consists of taking the sample from people who are available at the time the study is carried out and fit it to the criteria you are looking to test. We felt that it

Table 1. Usability Testing Current Tutorial

	Average General User Satisfaction
Terrible ----------Wonderful	3.5
Frustrating----------Satisfying	3.8
Difficult----------Easy	3.5
Boring----------Fun	2.0
Strongly Agree = 5, Agree =4, Neutral = 3, Disagree = 2, Strongly Disagree = 1	

was adequate in the sense that it was the population we wanted and the participants supplied very detailed information. The result showed that the participants particularly like the tool and how the tutorial conveyed the information to the students and teachers.

Table 1 represents data taken on the current tutorial that is on the site. Overall, people did not like the tutorial that was initially used and commented that it need drastic improvement. The participants noted that the current tutorial did not convey enough information to the user and would be complex to teach lesson from what was in the tutorial.

Table 2. Usability Testing of Revised Tutorial

	Average General User Satisfaction
Terrible ----------Wonderful	4.5
Frustrating----------Satisfying	4.8
Difficult----------Easy	4.5
Boring----------Fun	5.0
Strongly Agree = 5, Agree =4, Neutral = 3, Disagree = 2, Strongly Disagree = 1	

A moderate percentage of the participants answered that the tutorial was fun and overall satisfying in comparison to the older tutorial. The Anova results for each level listed in tables 3, 4, and 5. Our initial null hypothesis was done at a level of significance of 3.0. By looking at the P-Value we see that there is are differences between the two results.

Table 3. Anova Comparison Results – Terrible & Wonderful

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1 (table 1)	10	35	3.5	0.277778
Column 2 (table 2)	10	45	4.5	0.277778

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	5	1	5	18	0.00049	4.413873
Within Groups	5	18	0.277778			
Total	10	19				

Table 4. Anova Comparison Results – Difficult & Easy

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1(table 1)	10	35	3.5	0.277778
Column 2 (table 2)	10	45	4.5	0.277778

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	5	1	5	18	0.00049	4.413873
Within Groups	5	18	0.277778			
Total	10	19				

From the results, we see that the participants found that this tutorial conveyed the appropriate information to the teacher and student. Therefore, the overall revised tutorial makes it easier for the student to learn the suggested lesson with the Break Dancer tool.

Table 5. Anova Comparison Results – Boring & Fun

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1 (table 1)	10	20	2	0.222222
Column 2 (table 2)	10	50	5	0

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	45	1	45	405	8.65E-14	4.413873
Within Groups	2	18	0.111111			
Total	47	19				

4.2 Suggestions from Data Collected

The main suggestions that were collected from the data were to incorporate more lesson plans and to include more tests. In addition, one suggested that the lesson should be taught in a 3D lab to allow for more of an appropriate atmosphere for the Break Dancer tool. The participants did think that what we have now is very nice and would recommend that any teacher use this tool in their classroom. The participants found the Break Dancer tool fun and innovative. In addition, a great way to grab the students attention and teach a math lesson at the same time.

5 Future Work

The future work for this project is basically focused on implementing the software in Unity 3D for future use with Wii. That is our final ultimate goal for this project. There is work that needs to be done from evaluation viewpoint, including qualitative and long-term evaluation. One hypothesis is that a math game that engages students will motivate them in other Computer Science and IT course and encourage them to pursue these careers in college. By measuring student grades in the math pre-class and post-class, this could determine if the game engaged students sufficiently to improve their performance in later classes. We would also like to do a more rigorous evaluation over a six to nine week time span with some validated instrument to look more into our data analysis portion. We propose that we do a mini ethnography and sit in the classroom with the teacher to see exactly how effective the tool can actually be in a classroom setting.

In addition to implementing Break Dancer in Unity 3D, we need to find a way to implement the drag and drop interface. This idea was not implemented and will continue to be worked on for a future project. As stated earlier, the problem encountered is that the current interface only has two panels, and if you want to implement a scripting drag and drop interface, you need three panels. Therefore, we concluded that this task will be for a future project and that by then the initial designer will have directed us in the path that the group in the path that needs to be taken.

Other possible future work could be to explore other opportunities for game enhanced versions of other math courses, with the intention to motivate and improve the education of possible undergraduate students.

6 Conclusion

We implemented a better tutorial, lesson plan, and mini tests to help teach the lesson better and grab the user's attention. This factor will help to make the Break Dancer tool a better instrument for teachers as well as students. The CSDTs offer an exciting convergence of both pedagogical and cultural advantages. Computer games are very popular among children and adolescents. In this respect, they could be exploited by educational software designers to render educational software more attractive and motivating [5]. Unlike many other ethnomathematics examples, we can modify the interface to allow a close fit to the math curriculum, which makes it easy for teachers to incorporate into their class. At the same time, their ability to move between virtual and physical implementations allows use in the arts; and their historical connections provide teaching opportunities in history and social science. Most importantly, they allow for a flexible, creative space in which students can reconfigure their relations between culture, mathematics, and technology.

Research could help make games more attractive to different types of uses, and address the differences in the types of games that appeal to either sex. Females tend to be more attracted to games that involve relationship building than do males, who tend to prefer action games. Educational games also need to be culturally sensitive.

Acknowledgments. I would like to extend a heartfelt thanks to Dr. Cheryl Seals for being a great mentor during this research. A special thanks to Dr. Ron Eglash, for your support and contributions to the subject matter. I would also like to thank Rahul Potgan, Ravali Gondi, Human Computer Interaction Laboratory (Auburn University) and STARS Alliance members for their contributions in this project. All ideas expressed are through research and solely opinions/conclusions of the authors.

References

1. Culturally Situated Design Tools, http://www.rpi.edu/~eglash/csdt.html
2. Math and culture, http://www.commcorp.org/dys/pdf/DYSMath-Math Culture
3. Mathematical Games as an Aid to teaching Mathematics, http://www.bbc.co.uk/dna/h2g2/A798221
4. Ramer, W.: What Makes a Game Good. In The Games Journal (2000), http://www.thegamesjournal.com/articles/WhatMakesaGame.shtml
5. Salen, K., Zimmerman, E.: Rules of Play Game Design and Fundamentals. Games As Cultural Rhetoric. Massachusetts Institute of Technology, 515–534 (2004)
6. Virvou, M., Katsionis, G., Manos, K.: Combining software games with education: Evaluation of its educational effectiveness. In: Educational Technology & Society, pp. 54–65 (2005), http://www.ifets.info/journals/8_2/5.pdf
7. Claypool, K., Claypool, M.: Teaching software engineering through game design. In: Proceeding of the 10th Annual SIGCSE Conference on Innovation and Technology in Computer Science Education, ITiCSE 2005, Caparica, Protugal, June 27-29, pp. 123–127. ACM Press, New York (2005)