

Looking for Science and Mathematics in all the Right Places: Using Mobile Technologies as Culturally-Sensitive Pedagogical Tools to Capture Generative Images

María G. Arreguín-Anderson
Elsa Cantu Ruiz

University of Texas at San Antonio

Abstract

The exploration into cultural practices occurring in households has become more fluid and transparent process thanks to the presence of mobile technologies that allow members of a group to capture daily occurrences. This case study explored ways in which three Latino preservice teachers used mobile devices to discover connections between scientific/mathematical knowledge generated in their household and the academic curriculum. Through reflection and dialogue, three prospective Latino teachers were prompted to transform the focus of their exploration. The findings indicate that through prompted praxis our participants discovered science and mathematical connections in cultural practices emerging from their household.

Introduction

Mobile technologies (e.g., iPods, iPads, digital camera, video recorders, and cell phones) have emerged as possible venues for access to education and social equity empowering students to explore and validate learning spaces traditionally ignored in the academic context. With trends in media use indicating that 69% of all 8-18 year-olds have their own cell phone (Rideout, Foehr, & Roberts, 2010) and that a substantial number of young people “carry most forms of portable digital media to school with them” (Roberts & Foehr, 2008, p. 15) educators are faced with the task of designing instruction that integrates these technological devices so that students continue to learn while on the move. Hence, teacher preparation programs must equip prospective teachers with pedagogies that address the challenges and opportunities that the use of media technology entails. In this study we present the case of three Latino bilingual preservice teachers who, through dialogue and reflection, were prompted to use mobile technologies to explore their home as a valuable source of scientific and mathematical knowledge.

Theoretical Consideration for Mobile Learning

The practice of using knowledge that originates in non-traditional spaces can be traced to Freire’s (1994) use of locally generated words and images to conduct literacy circles and discussions closely related to the audience’s lives. This notion connects to the idea that households are sources of knowledge and skills that have been historically accumulated and culturally developed and are “essential for household or individual functioning” (Gonzalez, Moll, & Amanti, 2005, p. 72). The exploration into cultural practices occurring in households has become more fluid and transparent thanks to the presence of mobile technologies that allow members of a group to capture daily occurrences.

Operating under the Freirean premise that learning is facilitated when content introduced holds deep connections with one’s familiar context, we find intersections between scientific/mathematical learning and the use of generative images. Based on a critical framework, we define generative images as pictures or video clips captured directly by the students within their social and familiar space using technologies or devices such as their cell phone camera, digital camera, portable video recorder or any device at hand. Because these digital images emerge from authentic settings, they can potentially generate further explorations and discussions when brought to the classroom allowing teachers to connect students’ cultures to the official curriculum. However, “while a

situated curriculum is one way for the teacher to practice democratic authority, this is not a static entrapment in what students already know and say. What students bring to class is where learning begins” (Shor, 1992, p. 44). This type of students’ active involvement in the learning process opens the door to generative themes connecting academic, community, and home issues to the multiple contexts in which students learn while on the move contributing to solve the mismatch between the school and the outside world (Gonzalez et al., 2005).

In this sense, mobile learning “offers new ways to extend education outside the classroom, into the conversations and interactions of everyday life” (Sharples, Milrad, Sanchez, & Vavuola, 2009, p. 5). Sharples et al. (2009) advanced a theory that defines mobile learning as “the processes (both personal and public) of coming to know through exploration and conversation across multiple contexts, amongst people, and interactive technologies” (p. 5). They state that exploration is mobile and involves learning that may take place across space, time, and from topic to topic. Mobile learning has the potential to transcend general traditional dynamics usually found in minority classrooms and become a pedagogy of possibility and social mobility. Kim, Mirand, and Olaciregui (2008) propose that access to learning through mobile technology is a viable option worth exploring for underserved individuals and stated that “recent innovations in mobile learning technology offer promising opportunities to combat the deep seated chasm of inequality entrenched in Latin America and many places on earth” (p. 417) including the United States.

Review of the Literature

Mobile learning literature suggests that hand-held devices hold significant potential for learning and teaching (Johnson, Smith, Willis, Levine, & Haywood, 2011; Rideout et al., 2010; Sharples et al., 2009). Through a variety of innovative projects, teachers in K-12 settings have gradually engaged in the design of lessons and activities that are completed over a virtual space or beyond the confines of the classroom walls (Kim et al., 2008; Shuler, 2009; Valk, Rashid, & Elder, 2010). These opportunities to learn in asynchronous ways have changed traditional patterns of knowledge construction. Today’s emerging technologies allow learners to take a more active role in activities that are relevant, significant, and personalized.

The potential for enriched learning in the mobile era is currently maximized by students’ permanent access to devices that facilitate ‘anytime, anywhere’ social interactions (Lenhart, Ling, Campbell, & Purcell, 2010). This type of social skills are essential in a globalized world, thereby allowing students to widen the circles of collaboration and communication in project-based tasks that range from exploration of community resources at the elementary level to the study of chemistry terminology at the college level (Kolb, 2008; Pursell, 2009; Shuler, 2009). However, wide acceptance of mobile learning pedagogical design is still not the norm. Shuler (2009) warns that prior to launching formal initiatives in mobile learning, current cultural norms, and teachers’ negative attitudes represent a challenge that must undergo transformation.

Change of attitudes and beliefs in regards to technology is perhaps better addressed at the teacher preparation level. Gado and Ferguson’s (2006) research on the integration of mobile technology into a science methods course explored aspects of student learning that would be affected by hand-held based science activities. Their findings indicate that preservice teachers’ inquiry skills and organizational skills, engagement in science content learning, and attitudes and self-efficacy were enhanced. Scholars have also investigated the pedagogical and content knowledge relevant to the teaching of mathematics in primary and secondary schools that could be activated by the use of mobile technology (Chinnappan, 2009; Hlondan, 2010). These studies emphasized the role of the teacher in developing a good understanding and familiarity of the mobile technologies they will be using in class. Although these studies recognized the key role that technology plays in today’s classrooms, research is needed that situates the use of such technology within the dynamics of culturally and linguistically diverse settings.

Our study explored the educational potential of mobile learning and focused on this research question: What type of cultural and academic science and mathematics connections were identified as preservice bilingual teachers explored their home environment using mobile technologies?

Methods

The purpose of this study was to explore and describe the potential of mobile learning for scientific/mathematical inquiry with preservice bilingual teachers at a Hispanic Serving Institution (HSI) in south Texas. The instructor used mobile technology to complement and extend formal face-to-face class meetings as a regular instructional strategy. Mobile devices used in this course included cell phones, digital, and video camera. Initially, this intervention study involved 15 bilingual preservice teachers enrolled in one science methods course. All participants owned cell phones previously provided to them as part of a grant awarded by the Academy of Teacher Excellence (ATE). Given the intricacies of all data collected and our overall purpose to identify specific instances of home-school exploration with mobile technologies, we decided to focus on data produced by three students.

Participants

The authors utilized purposeful homogeneous sampling as the guiding strategy to select three participants based on characteristics that were consistent with the overall objectives of this inquiry (Miles & Huberman, 1994). We selected Carlos, Magda, and Perla out of the 15 preservice teachers because they sought bilingual certification EC-6 (race will not be a variable in this study); were enrolled in a science methods course; had access to a cell phone and other mobile technologies such as video recorder, and digital camera; and collected data in various formats.

Data Collection and Analysis

Data collection included semi-structured interviews, reflections, field notes, blog posts, and multi-media presentations. All students were interviewed during and after the semester. Additionally, we recorded field notes in 5 x 8 index cards limiting one topic per card in order to facilitate coding (Glesne, 2006). Maxwell (2005) proposed coding as the main categorizing and analytic strategy in qualitative research and defined it as a strategy that “applies a pre-established set of categories to data according to explicit, unambiguous rules” (p. 5). Miles and Huberman (1994) stressed the need to code field notes using predetermined categories as a prerequisite step in preparation for effective data representation or display. This multiple case study focused on the following categories: academic connections, cultural connections, and mobile technologies. Participants also created a personal blog in which they included weekly personal reflections, pictures, audio recordings, and interviews related to a variety of science and mathematics topics. Students used mobile technology to explore their households and other personal spaces as sources of scientific and mathematical knowledge. A preliminary analysis of students’ posts on their personal blogs revealed a noticeable absence of cultural significance within the events and objects captured leading the instructor to plan intervention.

Using Prompted Praxis

The authors chose prompted praxis as the intervention strategy for this study. Rodriguez, Zozakiewics, and Yerrick (2005) defined this strategy as one that seeks to solve the disconnect between “espoused beliefs” and beliefs in action. In a study conducted with inservice teachers Zozakiewics and Yerrick identified the need to intervene or prompt teachers to “reflect and take action in a manner more congruent with their stated professional development goals” (p. 357) as well as the goals of their project. This type of intervention can occur before, during, or after teaching and seeks to encourage transformative action. A similar approach was adopted in this course where the instructor identified opportunities for purposeful intervention. Focusing on praxis while teaching, in the next section the authors describe the type of dynamics that prompted the instructor to encourage reflection. Then, the results of such intervention are narrated.

Findings

Prompted Praxis while Teaching

As part of the requirements stated in the syllabus of the science methods course, preservice teachers completed an assignment titled: "Science and mathematics found at home." The general purpose was to compile digital images with cultural significance that could be connected to the science and mathematics curriculum. In order to allow sufficient time for discussion and feedback, the instructor divided students' individual presentations into two groups, each presenting on a different day.

During the first day of presentations, seven students described their projects. In most cases, students included pictures of objects and living organisms found at home such as a chair, a tree, and other items randomly selected and categorized under science or mathematics related topics such as states of matter, living things, geometrical figures, etc. Once again, the instructor noticed the cultural disconnect initially identified in the students' weekly blogs. After all presentations had concluded and an open discussion began, the instructor used a student's picture of rocks (see Figure 1) to pose a variety of questions. Field notes of this discussion reflect students' ideas of what they perceived as valid representations of scientific/mathematical knowledge with cultural relevance.



Figure 1. Objects found at a students' home.

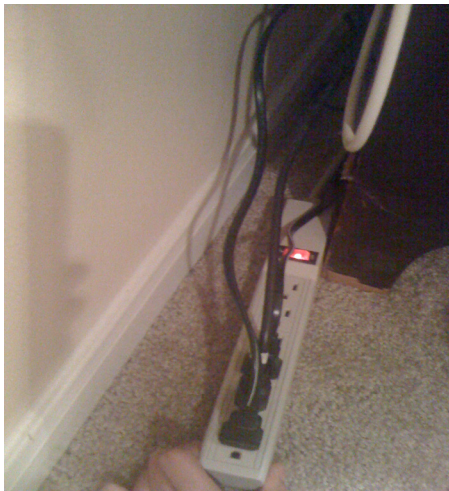
- | | |
|-----------|---|
| Professor | In what ways do we make culture at home? What does a rock represent to me? Does my family manipulate that rock in any way? Let's talk about objects that we manipulate. What happens when some of us get a stomachache? |
| Student 1 | Grandma makes tea. |
| Professor | What tea would that be? |
| Student 1 | Chamomile tea or spearmint tea sometimes |
| Professor | Isn't that part of our cultural practices? |
| Student 2 | Yes, but that is not in the TEKS (state curriculum) |
| Student 3 | Culture is in the TEKS but the tea is not. |
| Student 1 | Well, I guess when the water boils to make the tea then we actually witness part of the water cycle. |
| Professor | Great! So an herb or an object holds very little meaning if we do not act in relation to this object. |

So in a way we create culture. Let's think what other connections can we make? In what ways is scientific and mathematical knowledge available at home? Let's talk to our parents, our neighbors, our children, and see what we can find.

Generative Images after Prompted Praxis

The presentations designed during our second meeting included a variety of "generative images". In contrast to day one, students' pictures and video showed important changes in content (see Figure 2). In most cases, students began to identify objects, organisms, and experiences that could be dissected in terms of their academic and cultural significance.

**Day One Sample Images
Before Prompted Praxis**



**Day Two Sample Images
After Prompted Praxis**





Figure 2. Images presented on day 1 and day 2.

In this section the authors included three cases that were representative of the new focus undertaken by the students. A variety of comments reflected in field notes indicate this change in view, “I had to look at things with new eyes” stated Magda, who just like Carlos explored and inquired about their families’ activities related to the care and use of plants. A series of interviews revealed the significance of the topics selected, “Yo quería incluir esto porque esto era muy importante para él (his father).” [I wanted to include this, because it is important to him], stated Carlos. As part of his presentation, Carlos included an interview with his father, who eagerly shared a love for plants that could be traced back to his years in Nicaragua where he crossed the border with Honduras to work in a plantation. Although he now supported his family with income earned in construction jobs, plants remained his passion. Carlos’ recorded images showed his home’s backyard, a special place where his father cared for a variety of plants including trees and herbs such as guava, mango, grapefruit, papaya, fig, pepper, mint, epazote, and rosemary.

Magda’s cell phone and video recorder images also related to plants, however, contrary to Carlos’s father, Magda’s mother initiated this activity as a hobby which gradually allowed her to supplement the family’s income as she began selling plants in small pots at a local flea market. Magda’s presentation included pictures and an interview with her younger brother who initially grew epazote plants with the help of his mother out of curiosity, but later realized that those plants were in high demand at the flea market as ladies used them for culinary purposes. Encouraged by an initial sale, Magda’s brother expanded both the quantity and type of plants he grew.

During the second day of presentations students also captured images of family pets and farm animals, such as the case of Perla who included goats and an interview with a relative who raised them. In class, Perla explained how, the process of raising and caring for goats was labor intensive. She was particularly impressed by the techniques and equipment involved in dehorning the goats and added that “Ni idea tenía yo de lo que implicaba cuidar a las chivas”. [I had no idea about everything involved in taking care of goats]. Although her uncle was instrumental in the administration and management of the ‘goat business’ the entire family participated in different roles. Figure 3 shows scientific/mathematical connections that Carlos, Magda, and Perla identified in their home-family environment and shared with their classmates.

Sample Generative Images		Connection to Curriculum
	<p>Perla's Uncle:</p> <p>“Hay varios productos que se pueden elaborar con la leche de cabra, por ejemplo el delicioso dulce de leche quemada. Con un litro de leche y dos tazas de azúcar tienes.” [There are a variety of products that can be made with goat's milk, for example burned milk candy. All you need is a liter of milk and two cups of sugar].</p>	<p>Mathematics: Grades 3–5 Expectations (Measurement). Understand the need for measuring with standard units and become familiar with standard units in the customary and metric systems.</p> <p>Science: Grades K-4 Standards (Life Science) Children learn that all animals depend on plants. Some animals eat plants for food. Other animals eat animals that eat the plants (National Research Council, 1996, p. 129).</p>
	<p>Carlos's father:</p> <p>“Este es un palo de “grapefruit” a este también...cuando se siembra si la cubeta es de 6 pulgadas hay que hacer el orificio 12 pulgadas y echarle “mulch”.</p> <p>[It is a grapefruit tree... when you plant it if the bucket is 6 inches then you have to dig a hole that is 12 inches wide and cover it with mulch.]</p>	<p>Mathematics: Grades 3-5 Expectations (Algebra). Investigate how a change in one variable relates to a change in another variable (National Council of Teachers of Mathematics, 2000).</p> <p>Science: Grades K-4 Standards (Life Science) Children learn that plants and animals have life cycles that include being born, developing into adults, reproducing, and eventually dying (National Research Council, 1996, p. 129).</p>


	<p>Magda:</p> <p>En la casa mi mamá utiliza las naranjas y los limones para varios propósitos: cocinar, limpiar, etc. Con las cascaras de 15 limones y 1 litro de agua por ejemplo se puede hacer un limpiador. [At home, my mother uses the oranges and lemons for various purposes: cooking, cleaning, etc. Using 15 lemon shells and a liter of water you can make a cleaning substance].</p>	<p>Mathematics: Pre-K-2 Expectations (Number and Operations). Connect number words and numerals to the quantities they represent, using various physical models and representations; Science: Grades K-4 (Life Science) Standards- Humans depend on their natural and constructed environments. Humans change environments in ways that can be either beneficial or detrimental for themselves and other organisms (National Research Council, 1996, p. 129).</p>
---	---	--

Figure 3. Generative images and their connections to the curriculum.

Historical and Cultural Connections of Mathematical and Scientific Knowledge

Students discussed the cultural and historically accumulated meaning that plants and animals held for their families, as expressed by Carlos' father who stated that: "En mi ambiente era muy fácil aprender como sembrar productos para vender y comer porque el clima está perfecto para la agricultura, también tuve que aprender hacer esto porque era la única manera de sobrevivir en mi país." [In my environment, it was very easy to learn how to plan products that you could later sell and eat. The weather was perfect for agriculture, plus I also had to learn because it was the only way to survive in my country]. Magdas' brother also shared the cultural connections of the plant sold and commented "mi mamá y las señoras usan mucho el epazote para sus guisos y podemos hacer negocio vendiéndolas en la pulga" [My mother and other ladies use epazote as a spice when cooking and we can make business selling epazote plants in the flea market). In all cases, the activities stemmed from intergenerational practices such as 'goat raising' that reminded Perla's uncle of his childhood years in the ranch, "es lo que hacía mi padre y todo lo que yo sabía como niño y como adolescente." [this is what my father did and all I knew as a child and as a teenager].

Implications for Practice

Carlos, Perla, and Magda identified the pedagogical implications of a teaching and learning approach that establishes connections between the home and school: "This type of connections allowed students to experience real life learning. They can connect what they are learning in school with their home. This will definitely maximize their learning," expressed Carlos. In essence, preservice teachers perceived themselves as future 'agents of change', specifically in terms of validating parents as key participants of the education process as expressed by Perla who identified the potential for parental involvement:

Invitarlos y que vengan y nos ayuden a hacer una actividad y luego podemos relacionar eso con ciencia o matemáticas y es la mamá la que lo está presentando, entonces ellos a la vez se sienten orgullosos de su cultura, de sus padres, pero a la vez están aprendiendo ciencia de una manera diaria o sea de algo que ven a diario en casa y utilizando a los padres como un medio informativo va a ser algo que sí quiero hacer en clase. [I would invite them to come and help us with an activity which could later be connected to science or mathematics. All while having the mother present, so that they feel proud of their culture and proud of their parents while at the same time learning they learn science using what they see at home daily. This is something I definitely want to do in the classroom.].

In his future classroom, Carlos and Magda saw themselves integrating mobile technology in different ways. A camera, for example, can capture images that can be archived for later use in the classroom if there is no time to discuss such images at the moment. Carlos suggested a compilation of photographs sent by the parents through e-mail to be used when pertinent in connection with the curriculum. These pictures, taken with any mobile device can also reflect moments that are significant in students' culture, such as his own family tradition of making Naca Tamales (Nicaraguan tamales) from scratch. Magda talked about the possibility of having her students capture real life events using cell phone technologies such as the digital camera, Como la vez en que mis perros pescaron un tatuache y yo lo tengo en mi teléfono porque era lo único que tenía. O luego cuando se me descompuso la troca y le tomé fotos." [Like the time when my dogs caught a possum and I recorded it in my cell phone because that was all I had with me, or when my truck broke and I took pictures of it].

Generative images and Mobile learning: Implications for Teacher Education

Given current trends in media use, today's learners and educators possess tools to transform learning into a fluid process that transcends the walls of the classroom. With this in mind, teacher preparation programs are in the position to prepare educators to face the challenges posed by emerging mobile learning environments. There is a need to equip preservice teachers with pedagogical practices that are responsive to the needs of a technologically-bound generation whose mobility currently influences how they gain new knowledge and skills. This is crucial at a time when most children in the U.S. have access to a mobile device (Shuler, 2009) and 83% of teen cell phone owners already use their phone to take pictures (Lenhart et al., 2010).

The use of generative images to establish relevancy in the teaching of mathematics and science content is essential at a time when the interest and motivation of Latinos in STEM fields continues to show a significant gap as only 8% of STEM bachelor's degrees awarded in 2006 were received by Latinos nationwide (Dowd, Malcom, & Bensimon, 2009). The process of validating bodies of knowledge, or funds of knowledge, (Gonzalez, Moll, & Amanti, 2005) generated at home should begin with exposure of preservice teachers to experiential learning. In other words, there should be a systematic effort to immerse preservice teachers in the identification of knowledge found in their own environment to create awareness that can eventually lead to transformation of their own practices. The goal is to counter the deficit views of minority groups.

Conclusions

Generative images, as democratic tools, place learners in a position to construct meaning while advancing academically in the science and mathematics fields. This is particularly important for linguistic and culturally diverse learners whose academic advancement is often hindered by narrow representations of their cultural background in the school curriculum. Mobile learning technologies have now the potential to empower, validate, and extend the discussions of mathematics and science to often unexplored social spaces. A purposeful inquiry into historically and culturally accumulated bodies of knowledge can create personal connections contributing to a perception that science and mathematics occur everywhere. This exploration generated in non-traditional spaces can now transcend barriers and reach the academic environment providing the mirror so that minorities can begin to see their image reflected on the STEM arena.

References

- Chinnappan, M. (2009). Role of mobile digital technology in fostering the construction of pedagogical and content knowledge of mathematics. Retrieved from <http://ro.uow.edu.au/edupapers/83>
- Freire, P. (1994). *Pedagogy of the oppressed*. New York: Continuum.
- Gado, I., & Ferguson, I. (2006). Using handheld-computers and probeware in a science methods course: Preservice teachers' attitudes and self-efficacy. *Journal of Technology and Teacher Education*, 14(3), 501-529.
- Gonzalez, N., Moll, L. C., & Amanti, C. (2005). *Funds of knowledge*. Mahwah, NJ: Lawrence Erlbaum.
- Hlondan, O. (2010). Mobile learning anytime, anywhere. *Bioscience*, 60(9), 682.
- Johnson, L., Smith, R., Willis, H., Levine, A., & Haywood, K. (2011). The 2011 Horizon Report. Austin, Texas: The New Media Consortium.
- Kim, P., Miranda, T., & Olaciregui, C. (2008). Pocket school: Exploring mobile technology as a sustainable literacy education option for underserved indigenous children in Latin America. *International Journal of Educational Development*, 4(28), 435-445.
- Kolb, L. (2008). *Toys to tools: Connecting student cell phones to education*. Eugene, OR: ISTE Book Publishing.
- Lenhart, A., Ling, R., Campbell, S., & Purcell, K. (2010). *Teens and mobile phones*. Washington: Pew Internet & American Life Report.
- Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis* (2nd ed.). Thousand Oaks, CA: Sage.
- Pursell, D. P. (2009). Adapting to student learning styles: Engaging students with cell phone technology in organic chemistry instruction. *Journal of Chemical Education*, 86(10), 1219-1222.
- Rideout, V. J., Foehr, V. G., & Roberts, D. F. (2010). *Generation M²: Media in the life of 8-to 18-year-olds*. Menlo Park, CA: The Henry J. Kaiser Family Foundation.
- Roberts, D. F., & Foehr, U. G. (2008). Trends in media use. *The Future of Children*, 18(1), 11-37.
- Rodriguez, A. J., Zozakiewics, C., & Yerrick, R. (2005). Using prompted praxis to improve teacher professional development in culturally diverse schools. *School Science and Mathematics*, 105(7), 352-362.
- Sharples, M., Milrad, M., Sanchez, I., & Vavoula, G. (2009). Mobile learning: Small devices, big issues. In N. Balacheff, S. Ludvigsen & T. d. Jong (Eds.), *Technology enhanced learning: Principles and products* (pp. 233-249). Heidelberg: Springer.
- Shor, I. (1992). *Empowering education: Critical teaching for social change*. Chicago: The University of Chicago Press.
- Shuler, C. (2009). *Pockets of potential: Using mobile technologies to promote children's learning*. New York: The Joan Ganz Cooney Center at Sesame Workshop.
- Valk, J. H., Rashid, A. T., & Elder, L. (2010). Using mobile phones to improve educational outcomes: An analysis of evidence from Asia. *International Review of Research in Open and Distance Learning*, 11(1), 117-140.