On the Ball Field with the Negro Leagues: Software Development for a Local Museum

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Research in informal learning, such as that which happens in museums, indicates that of the variety of pedagogical models available to us, a constructivist approach serves to engage learners of all ages. At the same time, finding ways to tie classroom instruction to museum experiences poses its own challenges to learning. One way to reach consistency and coherence between the classroom and museum visit experience is to involve visitors in the creation of museum exhibits. When exhibits take form in computer software, the opportunity exists to extend the development process and the scope of learning beyond the exhibit's primary audience and build a partnership between software developers and visitors.

These learning theories and insights into technology's role in the classroom and in the museum, coupled with a partnership among students and faculty at the New Jersey Institute of Technology; Little Bytes, an educational product developer; and St. Philips Academy, an independent primary school in Newark, serve as the foundation for a comprehensive multiyear program in multimedia learning systems that brings college seniors studying software engineering together with primary school students and teachers in an effort to provide educational software, involving all students in authentic learning situations by having them participate in all phases of the software engineering lifecycle.

Through a development process known as participatory design, curators from The Yogi Berra Museum and Learning Center in Montclair, NJ teamed with 5th graders from St. Philip's Academy and undergraduates from New Jersey Institute of Technology to produce interactive software that assists visitors to the museum to: learn about the history of the Negro Leagues through chronology and biography; learn about statistics and probability through the databases that draw on records of individual players from the Negro Leagues; and learn about the geography of the state of New Jersey and much of the eastern US through the location of baseball fields and the travel routes between them.

Jonassen and Reeves[32] make the point that "the real power of computers to improve education will only be realized when students actively use them as cognitive tools rather than passively perceive them as tutors or repositories of information" (696). Johnson, et al[30] restate the premises of participatory design in concrete terms. "Participatory design rejects the assumption that designers design and users use, assuming instead that unless representative users are among the designers, it is unlikely that the system will make adequate use of the users' skills and talents or provide good support for their tasks" (141).

"Established models for project organization, project work, work analysis, etc. are commonly based on the implicit assumptions that the necessary knowledge somehow exists, making the process of designing a system mainly a matter of extracting the knowledge from the participants, be it users or developers. More often than not, these assumptions do not hold. Therefore, development projects need to be transformed from production processes to mutual learning processes. Learning must be built into the process, by changing the ways in which project groups work together" (144).

Discussions of pedagogy and instructional design often entail their impact upon the cognitive systems of learners, knowledge transfer, and efforts to organize, facilitate and evaluate learning activities (Bloom[4]; Mayer[38]; Gagné[22]; Bransford and Vye[6];

Gagné and Merrill[21]; Gagné, Briggs, and Wager[23]; Mayer[39]; Greeno[25]; Bransford and Schwartz[7]). Learning systems have, over the past twenty years, undergone a demonstrable shift in focus from those based in instructivist theory and approaches (logical positivism and identifiable/fixed truth) to constructivist concepts (knowledge as a social construction) and practices. Marton and Booth[36] "use 'social constructivism' as an umbrella term for a rather diverse set of research orientations that have in common an emphasis on what surrounds the individual, focusing on relations between individuals, groups, communities, situations, practices, language, culture, and society.

The main question we ask is, "How do the surrounding social or cultural, forces mould or make certain ways of acting and certain ways of thinking possible for the individual?" (11). Savery and Duffy[45] set out the following "instructional principles" for constructivist pedagogy in a classroom setting:

- Anchor all learning activities to a larger task or problem.
- Support the learner in developing ownership for the overall problem or task.
- Design an authentic task.
- Design the task and the learning environment to reflect the complexity of the environment they should be able to function in at the end of learning.
- Give the learner ownership of the process used to develop a solution.
- Design the learning environment to support and challenge the learner's thinking.
- Encourage testing ideas against alternative views and alternative contexts.
- Provide opportunity for and support reflection on both the content learned and the learning process.

Bouton and Garth[5], Bruffee[9], Johnson[29], Johnson and Johnson[31], and Dillenberg and Schneider[13], believe, as does Hiltz[28], that collaborative learning is "a learning process that emphasizes group or cooperative efforts among faculty and students. It stresses active participation and interaction on the part of both students and instructors. Knowledge is viewed as a social construct, and therefore the educational process is facilitated by social interaction in an environment that facilitates peer interaction, evaluation and cooperation." Moreover, researchers of museum exhibit design find value in a constructivist approach. George Hein[27], for instance, posits "proponents of the constructivist museum would argue that the viewer constructs personal knowledge from the exhibit [and] the process of gaining knowledge is itself a constructive act" (22).

Anderson, Lucas and Ginns[1] propose, "that the human constructivist view of learning can guide research and assist the interpretation of research data because it recognizes an individual's prior knowledge and active involvement in knowledge construction during a museum visit" (177). Indeed, these authors' review of the literature of constructivist views of learning in science museum yields concurrence in "the recognition of the importance of visitors' prior knowledge, their alternative conceptions, and the individual nature of the construction of meaning from experiences countered in the museum" (179).

We have used these constructs to provide educational software designed to introduce the history and landmarks of Negro Leagues baseball to visitors of the Yogi Berra Museum and Learning Center. The participatory design model of software development, articulated most clearly by Druin[14,15,16], tests the hypothesis that integrating this model into the product development will promote a positive response from the users of the software. There is a strong concordance between participatory design and constructivist tenets, such as that learning is highly individualistic in nature (Anderson, et al[1]), affording our partnership the opportunity to bring student, teacher and museum exhibit together in terms of its development, but also its use as a discrete learning environment and a springboard to the articulation and growth of learning in more holistic senses as well.

During the fall semester of 2003, the preliminary project team compiled the list and sequence of learning activities tied to the core curriculum standards for K-8 students in New Jersey in order to prepare building the five components to the software: *Back in the Day*, where visitors select a year between 1850 and 1950 to reveal the most prominent baseball facts and figures of that year, juxtaposed to historical facts that set the activities of the Negro Leagues into a broader context; *Talking Baseball*, which provides visitors with a roster of the Negro Leagues' Hall of Famers in which each name is hyperlinked to an original video interview introduced by fifth grade student who reveals a summary of highlights before the video begins; and *Play Ball*, which offers visitors a map of the United States that displays a baseball field icon where Negro Leagues teams played their home games. When used in conjunction with the timeline, visitors can determine the distances between ball fields, find out what modes of transportation were available for the teams to use, and compute the travel time. Visitors can also test their knowledge of teams and players by using the interactive quiz portion of this module. Correct answers add points, based on levels of difficulty, to a scoreboard while watching the game play in animation.

Field of Legends contains snapshots of hundreds of team players. Visitors click on a still image of the player to display biography and back-of-the-card statistics. In *Fantasy Team*, visitors use the information they've encountered to select players to build their own teams. Images of players are inserted into an individualized team photo that can be printed and saved as a souvenir of the trip to the museum.

During our initial meeting with the elementary school children in January of 2004, we discussed what our interface might look like, what might attract kids their age to find out more about history, geography, and math, and help shape the development of the product design. As Mumford and Henshall[41] put it, "To best understand system functionality, the software designer should interact with user-oriented and visually oriented team members to integrate results from the task analysis and scenario-building processes in their software design. By knowing the user goals ahead of time, the software developer need not guess at the desired functionality" (441).

During the winter and spring we met regularly to develop the game modules through storyboarding. The children's reactions, comments and suggestions were balanced by the abilities and limitations of the designers and the tools they used, as well as the data available to be used in the components. The 5th graders made several visits to the existing museum space early in the spring semester and gained exposure to the more traditional exhibits then currently in use. These initial visits also provided their teachers and the software developers the chance to build on the children's experience and elicit from them new ideas to incorporate into the software. Throughout the semester, NJIT students implemented the preliminary requirements of the design, as teams of programmers and videographers used Macromedia and Adobe development software to create student introductions to video clips, animations for the timeline and geography sections, and simulations, and C++ and JavaScript to create some of the interactive applications. The database of player and team statistics was built with PHP.

The complexity and novelty of this project, at the practical level, derives from our attempt to merge learning groups (students at different levels of education) in order to develop a learning tool that is used primarily outside of a traditional educational environment. At the theoretical level, we attempted to interweave participatory design and constructivist pedagogy with informal and free-choice learning constructs. After a discussion of informal learning and how our project reflects its basic premises, we conclude with an overview of our experience and suggestions for future work.

One of the current strands of research in science education concerns how people learn in informal environments, including museums. Leaders in the field, such as Elsa Feher and Léonie Rennie[20], ask how we can "use our ingenuity to investigate what happens when learning is of free choice and out of school?" (105). The policy statement proffered by the Board of National Association of Research in Science Education Ad Hoc committee consists of six aspects that can be extended and generalized to other domains. When developing this project, we focused on how each of the aspects could be addressed. Below are the particular aspects, followed by how we sought to meet the challenges they presented.

1. "Such learning is self-motivated, voluntary, and guided by learners' needs and interests, so certain aspects of learning are critical to investigate (e.g., the role of motivation, choice and control, interest, and expectations in the learning process)."

Informal learning settings are widespread and generally occur outside the classroom. Watching television, listening to the radio, surfing the Internet, checking books out at the library or visiting museums with friends and family are all examples of informal learning. John H. Falk[19], Director of Institute for Learning Innovation suggests, as a society we need to recognize and support the vast, important and successful learning enterprise that takes place outside of the classroom. Collectively, he states, these types of learning experiences encompass what is known as "free-choice learning," where people engage in voluntary, self-directed learning experiences based on one's needs and interests. Museums provide environments that promote free-choice informal learning, "because they afford unprecedented opportunities to explore, observe and sense a fairly limited set of contextually relevant, highly structured, concrete experiences; all within a socially and physically novel, but safe, environment. Equally, or perhaps more importantly, museums are also one of the few places left in our society where children can exercise a high degree of personal choice and control over their behavior and learning (x).

Recent studies, conducted by Campaign for Learning through Museums and Galleries, show that museums and galleries are among this new breed of learning suppliers, delivering learning that suits learners' needs, where and when they want it. It is believed that museums and galleries could be second most important learning infrastructure after schools. As a result museums have taken on a more hands-on rather than hands-off approach to creating exhibits for learning. Dea Birkett[3] states that young people tend to be turned on by keys and screen, as they might not be by display cases. Traditional forms of museum displays are passive and generally hands off. Computer-based interactives are hands-on, encouraging learners to touch, feel and participate. Jones–Garmil[33] suggests a successful computer interactive experience carry a potential educational function and use a technology that brings the museum into a contemporary framework.

At the Yogi Berra Museum, the Negro League software application is centrally located in the educational center. It is a self-paced application in which users can select any module to use in any order they choose from the main menu. Each module has been developed to serve as both an entrée and an electronic extension to the physical artifacts and multimedia exhibits that populate the museum. For our fifth-graders, the software served as a launching-off point for classroom instruction and projects that situate what they encountered at the museum in a larger context of U.S. history and geography as they pertain to sports and social history, urban and infrastructure development, and the nature of transportation over time.

2. "The physical setting in which learning takes place is extremely important, so this learning needs to be investigated in authentic contexts."

Sugata Mitra[40], a physicist from New Delhi, heads research efforts at New Delhi's NIIT and launched a program he calls "the Hole in the Wall experiment," whereby a high speed computer was placed in a rural area of his country as an invitation for kids to interact with it. He monitored the activity and surprisingly the kids who had never seen a computer before with little knowledge of English taught themselves to draw on the computer and to browse the Net. Mitra coined the concept "Minimally Invasive Education." This is a system of education where children are responsible for their learning, and adults intervene only when absolutely necessary. A pedagogic method driven by mere curiosity coupled with minimal interventions from a teacher leads the children to explore with peers and results in learning. Mitra's studies show that any learning environment that provides an adequate level of curiosity can effect learning and satisfy inquisitiveness.

In informal learning environments, children are encouraged to problem solve, collaborate and deal with real life issues. Our software allows children to use portions of the programs that attract their interest and address the issues that they are concerned with. When the software is used in a museum setting, previously visited exhibits can trigger curiosity and a sense of inquisitiveness that sets the stage for investigation, collaboration and new questions to be answered.

Negro Leagues software has challenging problem-solving activities that incorporate authentic real life questions and issues in a way that engage and encourage collaboration with other students, teachers and museum staff. For instance, the Play Ball module allows the visitors to select any Negro League team to compete and test their knowledge of teams and players by using an interactive quiz. Correct answers add points to the appropriate innings on the scoreboard.

3. "Such learning is strongly socio-culturally mediated, so research designs need to offer opportunities to explore social and cultural mediating factors including the role of conversations, social learning networks, cultural dimensions and the use of groups, as well as individuals, as the unit of analysis."

The history of Negro League baseball is an excellent springboard for learning about a wide array of social studies topics. First, there is the time period itself, 1850-1950, the era in American history preceding and leading up to the Civil Rights movement. The treatment of black baseball players and their limited opportunities precisely mirrors the treatment of African Americans in society at large during this time period. Learning about the segregated and second class treatment of Negro League players will help reinforce and increase student understanding of the social conditions which predominated in the United States in the first half of the 20th century.

Our Back in the Day module not only addressed statistical data on baseball teams and ballparks for a discrete period in history, but these baseball facts and figures are set into a context that describes historical events of the same period. Studying the Negro League and learning about the individual players also offers children role models and puts a fresh face on the struggle for social, civil, and economic quality. Students are more likely to remember information if they can learn about an individual such as Josh Gibson or Satchel Paige and empathize with his accomplishments and struggles than if they are simply presented with faceless facts and numbers concerning society as a whole. For this reason, Talking Baseball provides users with original video interviews of those Negro Leagues players who have been inducted into the Hall of Fame. A student who summarizes the highlights of the player's career as well as discusses why that player is important to him or her introduces each video.

4. "Learning is a cumulative process involving connections and reinforcement among the variety of learning experiences people encounter in their lives: at home, during schooling, and out in the community and

workplace. Research designs need to offer opportunities to investigate all dimensions of learning and their connections in a variety of settings across a span of time which will allow us to understand how these experiences are used and connected to subsequent experiences longitudinally."

Robert Marzano and Debra Pickering[37] of the Mid-continent Regional Educational Laboratory (McREL) discuss five dimensions of learning that encompass this aspect and support the informal learning approach and activity we are describing here.

Attitudes and perceptions: The fifth graders participating in the development of the Negro Leagues software had a genuine interest in the success of the software program in that they participated in the design, development, testing and installation of the program. They had a positive attitude in every aspect of learning about both baseball and the software development process. When they visited the Yogi Berra museum to view baseball artifacts and other hands-on exhibits, they listened to retired baseball players describing the atmosphere of night games during the 1930's. When the programmers had interface design and functionality questions that only the fifth graders could address, they provided answers that set the stage for effective learning.

Acquiring and integrating knowledge: When students are acquiring new skills and processes, they must become familiar with the steps or model, then shape the skill or process to make it real for them, and thereby being able to practice, retain and perform it easily. This project introduced through participatory design the elements of software development. This was the first time that the tech savvy group of fifth graders was exposed to the intricacies of software development. They use a variety of software programs all the time, but development of such was new knowledge and experience. Combining that new knowledge with their experience of using other types of programs opens opportunities to retain information, practice new skills and participate collaboratively with other learners.

Extending and refining knowledge: For effective learning to take place, extending and refining knowledge becomes an important activity. To achieve this objective research designs must put in place reasoning processes used by learners to extend and refine their knowledge. Students use the Internet and other resources to compare, classify and abstract information about players, teams, locations, transportation routes and statistics once they are back in the classroom. The activity in the *Fantasy Team* module initiates these inquiries, as visitors use the information they've encountered to select players to build their own teams. Images of players are inserted into an individualized team photo that can be printed and saved as a souvenir of the trip to the museum. Back in the classroom, students actually modify what they already know; even what they know is accurate.

Use Knowledge Meaningfully: Making sure that students have the opportunity to use knowledge meaningfully is one of the most important parts of planning a unit of instruction. Tasks that require decision-making, investigation, or problem solving are among the reasoning processes applied to meet this objective. Every module in the Negro League software program is a springboard to an extended learning opportunity. For 5th graders, after having the experience of participating in the development of the software, touring the museum, testing the software and using the software as visitors, learning was cumulative and meaningful.

Productive Habits of Mind: The most effective learners have powerful cognitive habits that enable them to think critically, creatively and promote self-regulated thinking. Participatory design is an approach to the assessment, design, and development of technological material and systems that places a premium on the active involvement of the potential or current users of the system, in design and decision-making processes. Participatory design model, described below, enables a level of discipline and habit for young learners.

5. "Learning is both a process and a product, so we need to investigate the processes of learning as well as the products of learning."

A foundational element of this application development is participatory design, which has three main goals. First, to develop integrated learning environments that support visual and verbal literacy. Second, to encourage learners to construct their own paths to knowledge, and third, to develop methodologies that offer a better understanding of what children want and need when using technology. Druin[16] has found that her test groups have been able to find common ground, overcome communication problems and generate helpful ideas. Having children as design partners permitted programmers to respond to and improve the parts of the software with which children had the most difficulty. Teachers were involved in the software development process to link the factors impacting their instructional practices with software designers so that the product supports both learning in the museum and the methodologies employed in the classroom.

A value added to this project is the opened door to increased collaboration with other educational organizations such as Montclair State University and elementary schools in Newark. NJIT seniors majoring in multimedia information technology created audio, video, animation and interactive calculation tools so that children can learn and explore, at the museum, social history, math and geography all through interacting with the Negro Leagues and their players. The college students' educational experience was the solving of an authentic problem: to develop software that will assist children and other museum visitors to become familiarized with US geography and history all through the game of baseball.

Following participatory design, there were extensive discussions and work sessions among teachers, students and software engineers. Students working with graphical user interface design interacted with the younger children to determine engaging elements and designs that are compatible with the software's functionality as well as the skill sets of the intended users. The children will learn a little about software development, but a lot about the subject matter at hand. In this process, learning becomes largely a function of action.

Malone and Lepper's[35] findings that concern "the design of instructional environments that are intrinsically motivating, that is, environments in which people are motivated to learn in the absence of obvious external rewards or punishments" (223) were factored into the development of the software. For children, a game environment for learning activities proved to be successful provided "the game had an explicit goal" (225). They suggest developers use techniques such as variable levels of difficulty, multiple levels of goals, and having information that is hidden. Another requirement for these students was that they had to factor in that, "The main contribution of individual constructivism is its emphasis on the learner's active role in the acquisition of knowledge. The main contribution made by social constructivism, claim Marton and Booth[36], is its emphasis on the importance of cultural practice, language, and other people, in bringing knowledge about" (12).

How did NJIT students benefit from the project? As Carver, Lehrer, Connell, and Ericksen[10] suggest, their designing multimedia learning systems through which both users and developers exercise a variety of skills extended learning beyond the use of specific software applications and programming knowledge in several ways. These include:

Project Management Skills

- Creating a timeline for the completion of the project.
- Allocating resources and time to different parts of the project.
- Assigning roles to team members.

Research Skills

- Determining the nature of the problem and how research should be organized.
- Posing thoughtful questions about structure, models, cases, values, and roles.
- Searching for information using text, electronic and pictorial information sources.
- Developing new information with interviews, questionnaires and other survey methods.
- Analyzing and interpreting all the information collected to identify and interpret patterns.

Organization and Representation Skills

- Deciding how to segment and sequence information to make it understandable.
- Deciding how information will be represented (text, pictures, movies, audio, etc.).
- Deciding how the information will be organized (hierarchy, sequence) and how it will be linked.

Presentation Skills

- Mapping the design onto the presentation and implementing the ideas in multimedia.
- Attracting and maintaining the interests of the intended audiences.

Reflection Skills

- Evaluating the program and the process used to create it.
- Revising the design of the program using feedback. (quoted in Reeves[44]).

The seniors must consider Greenfield's[24] reference to video games as "cultural artifacts that require and develop a particular set of cognitive skills; they are a cultural instrument of cognitive socialization. … Just as different kinds of games have, in the past, prepared children and youth for the varying adult skills required by different societies around the world … so too do video games prepare children and youth for a future in which computer skills will become even more crucial to thriving in a technological world" (87).

As Eisner[17] states, "Literacy, as I use the term, is the ability to encode and decode meaning in any of the forms of representation used in the culture to convey or express meaning" (x). Learning occurs in many forms, in varied environments, at times through the use of computing tools such as interactive software in multimedia formats. Several constructivist-based software design philosophies posit that there should be collaboration between the user and the designer when creating learner tools. There are differences between design strategies such as Harel's[26] and Kafai's[34], described below, which are found in the level of involvement of each of the stakeholders in each of the activities and roles during the design and development process.

Harel[26] has five reasons why she finds "'learners as designers' (or 'design for learning') is a rich paradigm for learning

- Design motivates learning.
- Designers make things happen. Design substantiates learning in actual accomplishments…. Passive learning and voyeurism can hardly exist in such an environment.
- Design evokes self-knowledge. Designers make personal connections between the affective and the cognitive. [Designing] as an educational process leads learners toward a productive and a personal (affective and cognitive) contribution to their learning environment.
- Designing a product promotes consideration of intended users, clients, customers – the community of others that designers serve.
- Design is integrative and holistic.… [Design] is viewed here as an empowering principle, as a discipline which facilitates other learning, and which marries cultural background,

> school activities, thought, action, creativity, construction and reflection. … Students learn how to integrate ideas. (xix-xxi)

Kafai[34], however, "argue[s] for a different approach, the learner as designer, thus breaking the traditional barriers between end users and system designers. … I propose this as an extension to the existing approaches for identifying users' needs and demands. … I see this as a privileged way for children, in particular, to learn about various subject matters (126). For Kafai, the three essential features of the software design cycle are:

- Designing educational software is crucial because it places children in the teaching situation and forces them to shift perspective between being a teacher and being a learner.
- Testing is included because children designers need to meet the prospective learners they are designing the software for.
- Evaluating other software designs is essential because students can apply the insights gained from their own design process.

In Brouwer-Janse, et al's[8] "User Interfaces for Young and Old," the authors find that the "challenge for designers of children's applications … is to enable children to reconstruct and build their own images of the world, to support the development of their reasoning, and to surpass repetition and rote learning of static concepts" (36). They also stress the positive impacts of collaboration, including "an efficient, effective way to get a feel for how children interact with their environment and their interests, leisure activities, hobbies and preferred games" (41). One difference between collaborative educational software design and other product under the domain of HCI is that "Designing for children means designing for fun. Human factors specialists, however, are trained to focus on product usability. This may be important for a fax machine, but it is less important for a computer game; that is, to a large extent, product satisfaction overshadows product effectiveness and efficiency" (42).

Ted Ansbacher[2] makes it clear that the road we have traveled here is not new, though it has often been neglected. In an article juxtaposing the main points of John Dewey's *Experience and Education*[12] with suggestions for cogent museum display and exhibit design, he states that, the teacher's job in a traditional school [is] communicating information to the students. If, however, once accepts Dewey's position that [museum] visitors develop learning from their own experiences, then the exhibition goals shift from the outcomes to the experiences themselves. The job of the exhibit developer and designer likewise shifts to one of creating an environment that will enable these experiences to take place (39).

Our work has been directed toward the goal of creating the bridges that connect disparate learning environments and bring them under one umbrella through activities and tools that are thematically and practically associated. As constructivist pedagogy continues to take hold and build stronger roots in traditional educational environments, the opportunities to make the connections and build the partnerships described here also grow. As exhibits in museums become more interactive, the opportunities for innovation in software development and other learning tools also pose new challenges that the adoption of old wine such as Dewey's, and new wine such as Druin's can successfully address. These learning opportunities, however, must take into consideration not only the merger of formal and informal learning environments, but also how both environments can best respond to intrinsic and extrinsic motivations to learn.

Csikszentmihályi and Hermanson[11] describe students "who are intrinsically motivated as having 'learning goals,' while students who are extrinsically motivated [as having] 'performance goals.'" Ultimately, both classrooms and museums should adapt to practices, tools and techniques that provide "the natural motivation to learn [and rekindle] supportive environments [and] meaningful activities by [learners] being freed of anxiety, fear and other negative mental states, and [having] the challenges of the task meet the person's skills" (35).

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