Learning Metaphor through Mixed-Reality Game Design and Game Play

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ABSTRACT
This paper describes a recent program for game-based learning within a mixed-reality environment, the Situated Multimedia Arts Learning Lab [SMALLab]. In the program, our research team collaborated with a 9th grade Language Arts teacher to design and deliver a new learning game and associated curriculum. Through the process of game-design and game-play, students advance their understanding of metaphor. We outline the theoretical basis upon which design decisions were made, and describe the rationale for choosing Language Arts as the subject area for this program.

Three goals structure our research: (1) to advance students’ understanding of literary devices with an emphasis on metaphor; (2) to engage otherwise under-performing students through game-based learning that is student-centered, collaborative, and based in reflective practice; and (3) to demonstrate effective game-based learning using a mixed-reality platform in a conventional classroom context. Twenty-four students attending a large suburban high school in the southwest United States participated in this learning experience once a week for seven weeks during the Fall of 2007. Our data indicates that these students attained a more globally coherent model of metaphor in the course of their participation, that they found both the game-design and the game-play process stimulating and rewarding, and that, given the necessary scaffolding, a mixed-reality learning environment can be effectively employed to teach standards-based curriculum in a conventional high school classroom.

Categories and Subject Descriptors
K.3.1 [Computer Uses in Education]: Collaborative learning, Computer-assisted instruction

General Terms
Design, Experimentation, Human Factors.

Keywords
K-12, learning, digital games, game design, education, play, game-based learning.

1. INTRODUCTION
In recent years, interactive media and digital games have been increasingly integrated into K-12 teaching and learning. Supporting this trend, there is a growing body of evidence that documents the exciting potential for well-designed game-based tools and curricula. When grounded in an appropriate theoretical foundation, game-based learning promises to have a transformative effect on the future of K-12 education. Specifically, game-based learning can be effectively structured by curricula that are student-centered, collaborative, and support reflective practice.

In the continuing effort to improve student engagement in learning and move the teacher from his or her perch as “sage on the stage” to “guide on the side”, curriculum designers over the last 30 years have embraced student-centered activity as the gold standard for classroom participation frameworks [1]. Student-centered learning activities are designed to elicit students’ reasoning about the concepts under study and encourage explicit sense-making over rote memorization and regurgitation of facts. Since the digital age has placed facts at students’ fingertips, the structuring of information into coherent and useful conceptual models is where schooling must focus its energy.

Student-centered learning by its very nature is collaborative as it relies on student-to-student discourse and joint activity to leverage the sense-making process. An extensive research base has demonstrated the efficacy of collaborative learning techniques [2]. Teachers manage this discourse, frame the target concepts and scaffold student thinking as needed, but students’ ideas and joint effort to make meaning ideally determines the direction of lessons.

Such inquiry-based and model-based learning environments design in and depend upon reflective practice to advance students’ conceptual model building, model testing and model application skills [3]. This typically happens in small group work, subsequently shared with the whole class, aimed at articulating relationships between and among the fundamental elements of a concept and articulating the rules by which they interact. Donald Schon has proposed a more generalized theory of reflective
practice [4] that can serve as model of student thinking in the context of game-based curricula. Schon defines two modes of reflection. First, reflection-in-action can be though of as thinking on one’s feet while actively performing a task they are trying to gain expertise over. During reflection-in-action, students can take on the role of an informal coach and instruct their peers during the reflective learning process. Second, reflection-on-action occurs as students consider the processes and products of learning, often through group discourse.

There is extensive research documenting the value of play in learning. Play can take many forms within different game spaces, but in the context of this study, we are informed by Jenkins’ definition of play as the capacity to experiment with one’s surroundings as a form of problem solving and the assertion that play can increase students’ motivation for learning, keeping them engaged and encouraging them to take risks [5]. Sutton-Smith describes how play has lead to some of the greatest human achievements in subject areas including science and literature [6]. Sutton-Smith notes the extent to which, play, especially for children, is a means of true empowerment.

Situating learning in a familiar context allows students to map new ideas onto existing conceptual models. These metaphorical mappings allow for inference about the relationships between unfamiliar ideas and help students build predictive models that are useful for solving problems [7, 8]. Games are an ideal platform for this type of learning, providing students with both arousal and control to motivate their engagement [9] with a fictitious world of which they are challenged to make sense. Moreover, there is growing evidence that games have the ability to hold the interest of a player for long periods of time, unlike traditional forms of media that are passive, because of the flow states that arise from engaging in an isolated, sensory activity [10].

A number of recent efforts have demonstrated the efficacy of game-based learning through game-play and game-design. For example, in SimCity2000, educators adopted a pre-existing commercial game platform, Sim City, for classroom use [11]. Students study urban geography concepts by iteratively designing virtual communities. During the process they assume the roles of urban planners, designers, and policy makers. In the River City project, educators and researchers created a massively-multiplayer game to address specific content learning goals through engaging game play [12]. The design of such a platform allowed educators to effectively design content into the experience rather than potentially work around the biases of an existing game. Game creation frameworks such as Scratch and Alice [13, 14] explicitly use the game-design process as a vehicle for learning. These platforms offer an exciting vision for the integration of game-design for learning, but thus far, much of the learning content resides in student understanding of the underlying procedural and technological elements that drive games. We have identified three trends that run through this prior work that suggest opportunities for continued research.

First, many current game-based learning experiences rely on traditional desktop and console computing interfaces. While readily accessible, they can potentially limit the expressive and communicative capacities of students. However, recent research in mixed-reality offers the opportunity to engage students and teachers in new ways. Mixed-reality environments integrate the physical environment with digitally mediated components, often in an immersive framework where direct human-to-human interaction unfolds within a mediated space. Despite their exciting promise, mixed-reality systems can be large and costly, posing an additional set of financial and logistical obstacles for classroom based learning.

Second, much of game-based learning has been most successful in the areas of science and technology to date. Nonetheless, language arts is fundamental to learning across all subject areas, and in addition to the pervasive use of games for language acquisition, there are many opportunities to engage core language arts content (e.g., metaphor, imagery, compositional structure) through game-based learning. Camille Utterbach’s installation, Text Rain [15] offers a compelling vision of how mixed-reality can potentially be applied to language arts learning. With an open-ended and expressive interaction framework, it has engaged a diverse audience of learners in numerous museums. However, Text Rain’s “discovery learning” structure does not address explicit content learning goals.

Third, digital games remain on the periphery of most mainstream school learning at present, and it can be a difficult challenge to implement innovative game-based learning in conventional classroom settings. As a result, many such initiatives are deployed in museum and after school programs.

Our research is informed by these three trends. We are pursuing a multi-faceted approach to the study of game-based learning. Specifically, we have developed a new mixed-reality learning environment. We are developing a replicable model for mixed-reality game-based learning in conventional classrooms. Finally, we are collaborating with language arts teachers and students to design, deploy and evaluate the efficacy of game-based learning. We present the context and results of a recent field test program for underserved 9th grade students in a regional urban high school.

2. RESEARCH CONTEXT

Over the past three years, our research team has developed a new platform for learning, the Situated Multimedia Arts Learning Lab [SMALLab].

![Figure 1. SMALLab mixed-reality learning environment](image1.png)

SMALLab (Figure 1) is a mixed-reality learning environment that advances situated and embodied learning by allowing the body to function as an expressive interface [16]. Within SMALLab, students use a set of glowballs to interact in real time with each other and with dynamic visual, textual, physical and sonic media through full body 3D movements and gestures. As such, it establishes a porous relationship between a physical learning context and digitally mediated components. For example, within
**SMALLab students can interact in a productive and embodied way with virtual spring-mass systems and they can change symbolic representations (all laid onto real space) that exemplify—and let learners produce—the core dynamics of force and motion in physics. For example, working in the *Spring Sling* scenario, students are immersed in a complex physics simulation that involves multiple sensory inputs to engage student attention. They can *hear* the sound of a spring picking up speed, *see* projected bodies moving across the floor, *feel* a physical ball in their own hands and integrate how the projected ball moves in accordance with their own body movements to construct a robust conceptual model of the entire system. In the *Layer Cake Builder* game they work in collaborative teams to re-enact the interdependent geological processes that formed the surface of the Earth.**

Physically, **SMALLab**, is a 15’W x 15’W x 12’H freestanding, interactive space. A rectangular trussing structure frames its open architecture and supports the following sensing and feedback equipment: a six-element camera array for *glowball* tracking, a top-mounted video projector providing real time visual feedback, four audio speakers for surround sound feedback, and an array of tracked physical objects (*glowballs*). A networked computing cluster with custom software drives the interactive system. **SMALLab** also provides an embedded set of high level authoring tools that allow students and teachers to create and adapt interactive learning scenarios. This authoring environment, the **SMALLab Core for Realizing Experiential Media (SCREM)** and an extensible media database served as the game design platform for our study.

**SMALLab** is designed to accommodate the real world financial and logistical constraints of today’s classrooms and community centers while delivering emerging interactive technologies directly to communities where it is needed most. Over the past two years, our team has deployed **SMALLab** in a series of successful programs that have reached over 25,000 learners through regional school and museum programs.

In Summer 2007 we began a long-term partnership with a large urban high school in the greater Phoenix, AZ metropolitan area. We have permanently installed **SMALLab** in a classroom and are working closely with teachers and students across the campus to design and deploy new learning scenarios. The student demographic is 50% white, 38% Hispanic, 6% Native American, 4% African American, 2% other. 50% of students are on free or reduced lunch programs, indicating that many students are of low socio-economic status. 11% are English language learners and 89% of these students speak Spanish at home. In this study, we are working with 9th grade students and teachers from the school’s C.O.R.E. program for at-risk students. The C.O.R.E. program is a specialized “school within a school” with a dedicated faculty and administration. Students are identified for the program because they are reading at least two levels below their grade.

After almost a year of classroom observation, it is clear that students are tracked into this type of program, not because they have low abilities, but because they are often underserved by traditional instructional approaches. Conventional classrooms for underperforming students are often highly structured environments that stress drill and skill learning activities [17]. As a consequence, teachers can come to have low expectations for students and student motivation is very low. Creativity, reflective practice, and complex problem solving are rarely emphasized.

In Fall 2007, we initiated a pilot study of game-based learning for language arts in **SMALLab**. We collaborated with a first-year, 9th grade language arts teacher in the C.O.R.E. program to design and implement a new game-based learning scenario and 9-week curriculum. During the seven weeks, students worked once a week, for one fifty-minute class period in **SMALLab**. Our team provided technical support for the learning activities, but the teacher lead all sessions. During this process we also pursued professional development activities with the teacher, but discussion of that process is beyond the scope of this article.

Given this context we established three goals for the study:

**Goal 1:** Advance students’ understanding of literary devices with an emphasis metaphor.

**Goal 2:** Engage otherwise under-performing students through game-based learning that is student-centered, collaborative, and based in reflective practice.

**Goal 3:** Demonstrate effective game-based learning using a mixed-reality platform in a conventional classroom context.

**3. THE METAPHOR GAME**

Through a series of initial planning sessions with the teacher, we identified metaphor as the content focus of the program for several reasons. First, from a pedagogical perspective, metaphor is a central component of the 9th grade curriculum. Our state’s language arts standards for grade nine state that students should be able use figurative language (e.g., metaphor, simile, imagery) that is both expressive and responsive [18, 19]. Our partner teacher indicated that understanding and use of metaphor are difficult skills that students typically struggle to master. Traditional instructional methods address this topic through a variety of language base approaches, but it is rarely explored in a multimodal or experiential fashion in the classroom. **SMALLab** technology affords the opportunity to teach and learn metaphor in these new ways.

![Figure 2. Pairs of students cooperate to grab images and text in SMALLab](image)

Second, from a research perspective, we looked to the National Council of Teachers of English [20] which suggests students must have a working knowledge of language structures, such as metaphor, so that the texts they read and the texts they write are accessible. Metaphors are a key element of expressive writing and must be taught in ways that allow for deeper thinking. The NCTE supports curriculum that encourage the exploration of multimodal metaphors including visual and text elements. This
allows students to visually represent textual elements in order to become more effective writers, and accords with students’ everyday experiences with text online and in print where text encompasses numerous modes [21]. Furthermore, recent research shows that just by adding a drawing element to the writing process, students can incorporate more metaphors into their poems and thus portray their ideas more expressively [22].

Lakoff’s seminal research establishes the power of metaphorical thinking in structuring our daily communication and experience [23]. He shows that much of our language and action is grounded in metaphorical thought. As such, beyond mere reading comprehension and writing, it is clear that an understanding of metaphor will benefit students in terms of their ability to undertake problem solving tasks and structure their thinking in a variety of future learning contexts.

Our team has created a new game for SMALLab, The Metaphor Game. It aids understanding of metaphor through student-centered, collaborative, and reflective learning. During the gameplay process, students generate new metaphors by linking different media objects together. During game-design process, students author new game levels by configuring sets of interactive text and visual elements.

3.1 Game Scenario

As pictured in Figure 2, pairs of students work cooperatively to play The Metaphor Game. Moving within interactive space, students see a set of media and text objects (Figure 3) that are projected as floating across the floor. Students discuss the objects and negotiate potential metaphors that might motivate a pairing. Using the interactive glowballs, students move toward a target media object, grab it, and drop it into a “metaphor bucket”.

![Figure 3. Images and text from a student-designed game level](image-url)

After two media objects are dropped into the bucket, students can reflect on the pairing and work together, possibly coached by their teacher or peers, to generate a final metaphor and justification. For example, if the words lost child and an image of a boat are dropped into the bucket, players can explain, “The boat is a lost child, searching for the harbor, its only mother.” The metaphor is “the boat is a lost child” and its justification is understood to be that the boat, unable to find a harbor, is lost, just as a lost child would look for its mother. The metaphor and justification is entered into the SMALLab media database, serving as a semantic link between the two source media objects. The pairing and metaphor are immediately accessible to students and teachers via the SMALLab Link [24] online environment.

This interaction is the template for the student-led game level design activities. During the game-design process, students collaborate in small teams of three or four. They use a combination of drawing tools (e.g., pen, paper, markers) and image software (e.g., Photoshop) to create new imagery. They specify game design details using a paper-based worksheet as shown in Figure 4. SMALLab provides a set of custom interaction authoring tools to upload images and text to the media database, annotate each object, and configure any combination of objects as a new game level. Due to time restrictions, our research team completed these basic configuration tasks outside of class time.

3.2 Game-based Curriculum

Our Metaphor Game curriculum unfolded over a period of seven weeks where students met in SMALLab once each week during the school day for a fifty-minute period. There were three phrases of the curriculum, with each phase divided into two activities, the game-design process and the game-play process. During the game-design process, students or teachers author new game levels for The Metaphor Game. When complete, these new levels constitute the game played during the game-play process.

The three curricular phases are teacher-led design, student-led design, and literature-based student-led design. The first phase spanned three sessions with the second and third phases lasting two sessions each. During the first phase, the full time was devoted to the game-play process since the game design occurred before the program began. During the second and third phases, one and a half sessions were allocated to game-design with the last half of one session allocated to game-play.

During the teacher-led design phase, the teacher worked in collaboration with our design team to create four unique game levels. Each level was designed around a set of familiar word combinations and this phase functioned as an introductory experience. A practice mode of sorts, the students learned the game-play process and practiced metaphorical thinking. This play-testing phase prepared them to take the role of designer in subsequent phases. During this phase, the teacher designed forty-nine metaphors and students generated twenty-six metaphors through their play.

![Figure 4. Metaphor creation worksheet from game-design process](image-url)

During the student-led design phase, students first engaged in a game-design process, working in collaborative teams. Picking from a set of twenty-five images presented by the teacher, each team could select four images. From that point, each team was tasked with devising a complementary set of four words to complete four designed metaphors and a justification statement, each relating to a theme of their choice. Once complete, these game levels were subsequently used by peer students. During this
of the metaphor, “waves are war.” The LSA database returns a score during the early stages of the program, a team of students created fourteen metaphors during the design phase and created eight metaphors during the play process.

To measure the originality of paired terms in student metaphors, we use the Latent Semantic Analysis (LSA) pairwise comparison tool [26]; we can rate each metaphor based on how semantically related the two elements of the metaphor are. LSA is a mathematical technique for extracting and representing the similarity of meaning of words or larger bodies of text. It constructs semantic spaces by measuring word co-occurrences in over 30,000 documents with over 90,000 different words for a total of 11 million words. If a particular pair of terms appears infrequently in the system’s body of text, the pair will receive a low score, thus indicating high originality. Conversely, if the pair appears frequently, LSA will yield a high number. For example, during the early stages of the program, a team of students created the metaphor, “waves are war.” The LSA database returns a score of 0.01, revealing that this pairing of terms appears very infrequently. Thus, the metaphor ranks very highly along the originality dimension. By contrast, another student generated metaphor, “fear is loneliness” ranks low in originality with an LSA score of .47. For clarity, in Table 1 we subtract the LSA pairwise ranking result from 1.0 to present average originality scores so that higher values indicate greater originality.

During both the game-design and game-play phases, students were required to explicitly record a metaphorical justification for the pairing of each of their pairings. To measure the dimension of metaphorical aptness, eight experts from our research team rated each of these metaphorical justifications on a scale of 0 – 2. A rating of 0 indicates poor aptness, while a rating of 2 indicates high aptness. For example, a student generated metaphor, “surgery is war because every move might be your last” received a high average aptness score of 1.75. By contrast, the metaphor “the flamingos are a class, because they learn from each other” received a low score of 0.5.

Table 1 summarizes the average scores for both originality and aptness during each phase of the curriculum. Aptness measures are not available for the teacher-led design phase because the teacher did not provide justifications. n indicates the number of metaphor pairings analyzed in each phase.

<table>
<thead>
<tr>
<th>Table 1. Summary analysis of student-generated metaphors</th>
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<tbody>
<tr>
<td><strong>Game Design Phase</strong></td>
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<tr>
<td>Teacher-led design</td>
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<tr>
<td>Student-led design</td>
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<td>Literature-based student lead design</td>
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We see four meaningful trends in this data. (1) With each new phase of game design process, there is a progressive increase in metaphor originality and aptness. This increase is most pronounced in the transition from teacher-led design to student-led design. (2) There is a progressive decrease in originality and aptness with each phase of the game play process. (3) In the first two phases, students created stronger metaphors during the game-play process than during the game-design process. By the final phase, when students build from Shakespeare’s Romeo and Juliet, students created stronger metaphors during the design process than in the play process. (4) Once the student-led game-design activity is introduced in the second phase, there is a dramatic decline in the number of metaphors created by students during the game-play process (i.e., n = 26, 9, 8 for phases 1, 2, and 3 respectively).

Reflecting on these trends we draw three conclusions regarding the relationship between curriculum design and student performance. First, during the teacher-led design phase, students are able to create metaphors that exceed the originality scores of the designers. This phase of the curriculum was designed to introduce students to metaphor, where the teacher as game-designer is able to scaffold student learning. Here, as proposed by
Gee [8], we see an example of good game design intersecting with curriculum design for the benefit of students.

Second, during the student-led design process, there is a marked increase in both the originality and aptness scores. Metaphors created by students during the design process are stronger than those created by the teacher or during any of the game play processes. We posit that the during the design process, students challenge each other to build from scratch functional models of metaphor. During the game play process they are tasked to apply this model, a task which requires less effort. As a consequence, students are able to generate more powerful metaphors during design than play. From the perspective of Schon’s theory of reflection, the play process is an example of learning via reflection-in-action while the design process is an example of learning via reflection-on-action. Our data suggests that while students achieved gains during the design process, in future work, our curriculum should build in more time for the play process.

Building from this point, we draw a final conclusion. Simply put, during the second and third phases, game play was viewed by students and the teacher as an afterthought to the game design process. Review of the learning session documentation, combined with the raw numbers of generated metaphors demonstrates a drastic reduction in time-on-task from the first phase, and a hurried approach to thinking and learning through play. We conclude that this fact is a second contributing factor to the decline in student performance during game play in spite of the increase during game design. Again, we conclude that in future iterations, play must be established as a valuable and necessary component of the learning process. Furthermore, the play process should be appropriately facilitated at every stage, offering substantial mentoring in early stages, and encouraging peer coaching as students advance.

**Goal 2: Engage otherwise under-performing students through game-based learning that is student-centered, collaborative, and based in reflective practice.**

At the beginning of this program our partner teacher noted that student motivation and engagement is probably the greatest obstacle for student learning in the C.O.R.E. program. The metaphor game and curriculum was designed to engage students in novel ways that are rooted in a foundation of proven learning theories.

We now present a brief transcription of an early interaction between three students and the teacher during the first game-play process. Evan and Gina are working as a pair in the space. The teacher and another student coach the team. The group is reflecting on the pairing of an image of a long hallway and the word “love” that students initially paired during their interaction. They work through several ideas before arriving at a final construct. Note how students work together, with scaffolding instruction by their teacher, to craft a successful metaphor. As such, the game play process is framed as a cooperative endeavor where all participants reach shared success through their achievement. The resultant metaphor (“Love is a long hallway with many doors and many opportunities”) ranks highly with an originality score of 0.91 and an aptness of 1.625.

**Teacher:** What is your sentence?

**Evan:** Love is a long hallway

**Chris:** WHY is it a long hallway?

**Evan:** because…

**Teacher:** try not to say “because”. Love is a long hallway doing what?

**Chris:** Love is never ending! [laughs]

**Evan:** Because it is endless.

**Chris:** There is always a door at the end of it. Have you thought of that?

**Teacher:** OK, Chris came up with something different. Yeah maybe talk about the doors?

**Gina:** Love has many doors.

**Teacher:** So love is a hallway with…

**Gina and Evan together:** …many doors!

**Teacher:** and…

**Gina:** many ways to… I don’t know…?

**Chris:** FIND LOVE! [student claps and snaps his fingers]

**Evan:** many different opportunities… OK, so love is a long hallway with many doors and many opportunities.

In post-session interviews, students expressed high motivation for this type of game-based collaborative learning in SMALLab. For example, one student remarked, “I think our school would have better scores on reading and writing and stuff because SMALLab brings fun, and then when you think of reading and stuff you think of SMALLab and you think of a way you could do it yourself at home…except for without all the cool technology…as you’re reading out loud you could make your own sounds and your own extra little things…” Another student noted, “I like the fact that we’re in groups rather than by ourselves.”

Students also expressed a strong sense of ownership for their learning process and a desire to play a role in designing future SMALLab learning activities. One student expressed the desire to not only design student-centered learning activities, but to empower students to shape the curriculum for the benefit of their teachers: “The teachers will teach the students what to do first, and then the students should teach the teachers how to be fun with the program. So then the next step the teachers take--the next time they do it…they’ll know what the students like for the next generation class.”

In the following transcription, two students express ideas for how to structure a game-based curriculum. They explore how their experience could be transferred to other content areas and describe the value of integrating game-play and game-design.

**Interviewer:** Can you think of a way that SMALLab could be used in a math class?

**Chris:** You can use it to like divide and stuff… the teacher could show…like… I think people would pay more attention…like…honestly, I think people would pay more attention if they had more fun in their classes. If it was fun, people would pay attention. Cuz teachers are like “you gotta do this and that” and people don’t understand. People say they don’t understand the teachers way and they [teachers] want to help them
but they can’t find a way to help them. And actually students like listening to each other more than the teacher.

**Interviewer:** Do you wish you guys were at the computer? I mean, do most people want to be on the floor, or would it be worthwhile to develop activities where students were actually at the computer?

**Joe:** Yeah. Because when we were doing the metaphor exercise, when we were behind there it was like a behind the scenes of it, you know? We saw what they did and when they finally picked a metaphor we would name it…and just all the stuff that goes on on the computer that makes the SMALLab work…it’s pretty cool.

**Interviewer:** So you feel like that’s something…that we should be making that learning experience on a broad scale basis? Or just for the people in the class that might be interested in that?

**Chris:** Uh…broader scale.

**Interviewer:** Broader scale? Let everybody have a turn at that? [speaking to student 2] Have you been behind the computer?

**Joe:** No, but I think it should be like, pair up so that there’s 3 to a team, and we have, like, everyone names their own team and we play. Like, an elimination game. One’s at the computer and the other two are just thinking of metaphors…they can still go to their other partner to figure something out…and just like…have fun with it.

Later in the interview, the students discuss how SMALLab’s architecture supports a shared experience of cooperative gameplay in a large classroom of students:

**Interviewer:** So do you think that even the people who weren’t the players would be paying attention? Because one thing that I noticed standing by the side was that, certain activities, the people that were around the floor would tune out. Some things they were really tuned in to and the one thing that I noticed was, they were tuned into sounds…[both students nod]. When the system makes sounds people pay attention.

**Joe:** It’s funny.

**Chris:** Sometimes…for me… I like picking a person for anything, whether it be a sports team, a reality show…anything that people are competing against, I’ll pick someone, and that’ll keep me watching the show because I want my pick to win.

**Interviewer:** So…even though you’re watching outside the space you have somebody inside the space that you are rooting for…

**Chris:** Yeah.

**Interviewer:** Huh. What a good idea. I never thought about that.

**Joe:** It’s like you have your own cheer team.

**Chris:** And that’s what keeps me tuned in while other people are being tuned out.

**Interviewer:** And you don’t think that just that person’s team is going to root for him? You think the whole class will root for him?

**Joe:** I think everybody just wants to play…like get into the game…it’s like a football game…people cheer for their side—people cheer for their team…they want to root for their team…it’s like, why would you want to cheer for the other team? But still it’s your friends—you cheer for ‘em. And people are just like…we want to have fun.

**Goal 3:** Demonstrate effective game-based learning using a mixed-reality platform in a conventional classroom context

Through this pilot program our team has worked toward a replicable model for bringing innovative mixed-reality learning experiences into everyday K-12 classrooms. To do so effectively requires the design of learning activities that align with and enrich ongoing curricula. It requires professional development and support for participating teachers. Finally, it requires long term buy-in from all stakeholders including students, teachers, and administrators. Through quantitative and qualitative data presented above, we have documented several positive trends in student learning and evidence of their buy-in to the program. As a result of this study, a number of developments suggest that there is growing support and buy-in from the school. First, we have since engaged a number of additional teachers who are collaborating to develop game-based learning activities in SMALLab in content areas including Chemistry, Earth Science and Language Arts. Second, looking ahead to the next academic year we are working with the school administration to expand the program. Through this expansion we will partner to bring this model to the entire campus across all grade levels and subject areas, forging an onsite community of practice around game-based, mixed-reality learning.

5. CONCLUSIONS

We have presented results pertaining to three primary goals: (1) Students have achieved measurable learning gains in the course of this nine weeks unit of instruction. More significantly, they volunteered substantive recommendations about future game design and testing. (2) As illustrated above, students expressed high interest in working in the SMALLab environment. (3) We have demonstrated that SMALLab is an effective learning tool in the traditional learning paradigm of K-12 schooling.

SMALLab has been used for an entire year now in a conventional high school language arts classroom. Students look forward to their weekly work in SMALLab and offer suggestions on how SMALLab would be useful in their other classes. They even ask to play with SMALLab learning scenarios during their lunch hour. Teachers and administrators are pleased with this pilot study and are enthusiastic about extended access to this unique learning environment to other disciplines and student communities.

We hope to extend the current game architecture to include 3d movements and gestures. Students can enact movements within the space that can be archived as 3d data. This data can animate their media within the space. Their media will become more sprite-like and thus add a kinesthetic element in the representation of metaphor.

We will also explore the use of LSA as a scoring tool as students have expressed an interest in earning points and in having ways to compete with one another. If students know that they could achieve a high score by linking media together that are more original, they may challenge themselves to come up with metaphorical pairings that are more creative and more expressive.

We will continue to look for ways to improve the curriculum to better address content learning goals and pedagogical approaches with particular attention to perfecting the participation framework to optimize whole group engagement. We will also look for ways to empower students to make substantive contributions in the design of learning scenarios. This study reveals that learning was best fostered through the study of existing literature and game-
6. ACKNOWLEDGEMENTS

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8. REFERENCES


