The Source: An Alternate Reality Game to Spark STEM Interest and Learning among Underrepresented Youth

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Abstract

Alternate Reality Games (ARGs) are multiplayer role-playing games that use the real world as their primary platform and incorporate a range of media, including video, audio, email, mobile technologies, websites, live performance, and social networks. This paper describes the development, implementation, and player reception of *The Source*, a novel ARG designed to spark STEM interest and learning among youth from populations traditionally underrepresented in STEM fields. The *Source's* design was informed by the existing literature on recommendations for engaging underrepresented populations in STEM careers, specifically emphasizing social support systems, technology, transferable skill-building, and the relevance of STEM topics to youth from underrepresented groups. Our preliminary evaluation sheds light on some of the highlights, concerns, and lessons learned from implementing this youth-oriented ARG for out-of-school STEM learning.

Keywords: Alternate Reality Games, STEM, underrepresented youth, adolescents, skill-building, social support

Introduction

There is increasing recognition that the United States (U.S.) needs a workforce with better knowledge and skills in the fields of science, technology, engineering, and math (STEM) (NSF, 2010). Creating a STEM-educated population entails recruiting students with recognized and proven STEM talent, as well as those who may lack access to STEM education and training to cultivate their interests and abilities (Subotnik, Tai, Rickoff, & Almarode, 2009). As the country's economy and demographics change, non-participation of growing population subgroups places the U.S. at a disadvantage for talent and innovation (NSF, 2010). In the U.S., African Americans, Latinos, and Native Americans earn less than 15% of undergraduate degrees in engineering, math, and the physical sciences (NSF, 2013). Similarly, in 2009, women represented only 18% of engineering undergraduates (NSF, 2013). The lack of racial-ethnic and gender diversity among those pursuing STEM education and careers produces representational imbalances, decreases job opportunities for members of underrepresented populations, and narrows possibilities for innovation in both the theoretical and applied sciences (Davis, Ginorio, Hollenshead, Lazarus, & Rayman, 1996).

Disparities in educational opportunities contribute to underrepresentation. While the majority of American youth are exposed to STEM content in school settings, out-of-school programming may be particularly important for sparking STEM interest. These programs can encourage greater creativity and interest-driven exploration than traditional school-based learning (Bell, Lewenstein, Shouse, & Feder, 2009; Dabney et al., 2012; Hooker & Brand, 2009; Mosatche, Matloff-Nieves, Kekelis, & Lawner, 2013; Tyler-Wood, Ellison, Lim, & Periathiruvadi, 2012). Informal and community-based learning have the potential to incorporate the everyday experiences of students, exposing them to science-oriented media and participatory opportunities. A number of studies have suggested that programs grounding STEM learning in real-world problems and applications may advance young people's STEM knowledge and interests (Aschbacher, Li, & Roth, 2010; Barton, Tan, & Rivet, 2008; Greene, Lee, Constance, & Hynes, 2013; Shernoff, 2010).

Games for STEM learning

Within this literature, emerging research has sought to use games to improve STEM learning (Mayo, 2009). Games open new possibilities for learning, as computer, video, mobile, and analog games foster curiosity, optimism, and motivation about the possibility of completing challenges (McGonigal, 2011). Unlike learning in school, where academic failure can have serious negative consequences, games are one of the few cultural forms that encourage "safe failure" (Chess & Booth, 2013). In games, failure is treated as a learning opportunity and players are presented with myriad opportunities to take risks, practice new skills, and persist through challenges. In addition, games can foster and reward collaboration, cooperation, and creativity among players (Jenkins, 2004; McGonigal, 2011).

A subset of games, Alternate Reality Games (ARGs), are not bound by any single medium, hardware system, or console; instead, the real world serves as a storytelling platform with clues, puzzles, and narrative revelations combined with everyday objects, situations, and technologies. ARGs incorporate a range of media, such as text, video, audio, email, mobile technologies, websites, live performance, and social networks (Stewart, 2006). To solve a puzzle, players might need to find an object, complete an online quiz, or respond to a character via social media. Unlike other types of games, ARGs break down the spatial, temporal, and social boundaries within which people ordinarily learn and play by blurring absolute distinctions between everyday life and the game world (Montola, Stenros, & Waern, 2009). Recently, educational ARGs have been used in the classroom and within academic curricula (Bonsignore et al., 2012; Chess & Booth, 2013; McGonigal, 2011; Stokes, Watson, Fullerton, & Wiscombe, 2013). ARGs have the potential for use in STEM education; more information is needed to determine the feasibility and acceptability of ARGs for promoting STEM interest and learning among underrepresented youth.

The Source: an ARG to advance STEM participation

This project developed and studied *The Source*, an ARG designed to foster STEM-related knowledge, interest, and skills. The Source was played during the summer of 2013 by high school students recruited from the South and West sides of Chicago. These communities are predominately African American and Latino. This paper describes the development, content, and reception of this game-based, out-of-school STEM experience based on focus groups and in-depth interviews. It discusses lessons learned and recommendations for future research with ARGs for STEM learning. *The Source* was developed by The Game Changer Chicago Design Lab (GCC Design Lab), a university-based lab comprised of faculty, staff, graduate and undergraduate students, and local high school youth. The GCC Design Lab designs narrative-rich games to promote learning and reduce health risk behaviors.

An overarching narrative unfolded over five weeks to guide the players. *The Source* tells the story of Adia, a 17-year-old African American girl living on the South Side of Chicago, and her two friends: Ros, a designer and social media user; and Micah, a skilled computer programmer. In the first video, Adia provides the game prologue

Week	Theme	Activities	Learning Objectives
1	Engineering, Urban Planning, and Sustainability	• Quad Scavenger Hunt • Crossroads • MSI Scavenger Hunt • Power Play • Tower Building	• Introduce alternate reality games • Develop efficient problem solving skills • Foster collaboration and team bonding
2	Science, Reproductive Health, and Community	• Plagues, Trains, and Automobiles • Caduceus Quest • Infection City	• Show perspectives on healthcare • Introduce logic and critical thinking inherent to sciences • Learn basic concepts in epidemiology
3	Math, Cryptography, and Preventing Youth Violence	• Cryptography tutorial • Secret Society • Encoded letters from the father • Investigation • Tales from De-Crypt	• Learn about ciphers, such as Caesar shifts • Develop logic skills and deductive reasoning • Introduce frequency analysis
4	Technology and Immigration	• Hacking Challenge • War of the Worlds • Robot Party! • Wednesday Workshops • SAVE.exe • Technotopia	• Introduce themes of technology in social media and computing • Introduce basics in algorithmic thinking • Expose players to various careers in technology
5	Art and Storytelling	• Online activity • Meet the Middletons • Game *The Source* • Art Institute Scavenger Hunt • Ludorum Rassa • Insane in the mAImbrane • Helping Adia	• Basic game design techniques • Learning problem solving through story-based problems and collaboration • Reinforce cryptography skills from Week 2

Table 1. The Source Weekly Learning Objectives and Corresponding Activities

wherein she recounts finding a letter that is hidden under her mother and stepfather's bed. The letter, from her estranged father whom she has not seen in 12 years, describes a difficult game that he created for her. Given the quantity of challenges, Adia recruits other young people to help her complete the game by posting the video to the internet. Three high school-aged youth from the local community delivered the story via webisodes (short digital video clips interspersed with photos and clips from television shows and other popular culture works), social media, and a final interactive roleplaying session in which they revealed themselves to the youth players.

The three protagonists guide the youth through the summer activities and communicate with them through a variety of social media platforms. They challenge youth to unravel the central mystery posed by Adia and her friends while exploring current events and social justice topics.

An overview of the summer program appears in Table 1 and a detailed timeline of activities can be found at http://bit.ly/1oKl2ml. *The Source's* narrative, game activities, and implementation logistics were designed to address recommendations for engaging youth from underrepresented groups in STEM. Specifically, activities included: cultivating social support systems through collaborative teamwork and mentoring, incorporating technology, building transferable skills, and demonstrating that STEM is relevant to youth (Chang, 2002).

To foster social support, youth were randomized to 13 teams of approximately 10 players each; two mentors led each team. Mentors were graduate and undergraduate students who competitively applied for the position and were selected based on their (1) experience working with youth; (2) STEM abilities; (3) game design and gameplay experience; and (4) research/educational interests. Each team was assigned an animal name (e.g., Team Turtle, Team Spider, Team Rhino) and a logo. Players, mentors, and staff also wore *The Source* t-shirts to mark their shared objective and community. The ARG consisted primarily of collaborative games in which the teams collectively tackled common challenges—all players winning or all players losing. Activities also often required that team members help one another and combine their individual talents toward group efforts, facilitating peer-to-peer learning and collaboration.

Technology played a central role in multiple implementation logistics and game activities. Youth joined a central website in order to create individual profiles (with personal description and game activities), view both team and individual points, and track their teams' positions on the leaderboard. There was also an online discussion board, where youth could post responses to Adia's questions, communicate with one another, and pursue additional game-based challenges. Youth learned about large-scale energy systems, used a 3-D printer, and met with STEM professionals who explained how they used these technologies in their jobs and daily lives.

The participatory nature of the ARG form accommodated a variety of activity formats and settings for each learning objective, cultivating not only familiarity with STEM content but also building skills that can be applied not only in the game but also in academic and professional contexts. A central theme of the narrative was that Adia's father was an engineer and wanted her to learn technical skills that would help her in life. To ensure youth had opportunities to put what they were learning into practice, players participated each Friday in online or face-to-face skill-building sessions to learn photography, web design, and other skills. In addition, *The Source* linked real and virtual worlds by having players move across multiple locations and media, learning and practicing skills on the university campus or in major city institutions (e.g., museums).

Each week focused on a different STEM topic selected to link STEM learning to important local and national health and social justice issues, such as sexually transmitted infections (STIs) and youth violence. Youth were positioned as problem-solvers rather than victims, as the South Side of Chicago (the setting for this program) has disproportionately high rates of these issues ("Chicago crime rates by community area," 2014; *HIV/STI Surveillance Report, Chicago,* 2013). For instance, to learn about epidemiology, players played a board game called "Infection City" which simulated a pandemic. The goal was to eliminate two rampaging diseases that spread according to specific patterns. Players had to collaborate, strategize, and plan ahead in order to analyze where the diseases would spread next. In "Caduceus Quest" students were tasked with solving public health problems based on newspaper headlines. They then recruited teams to

help develop a comprehensive "pitch" or proposed solutions to receive grants from mentors to solve the public health problem. Youth violence, on the other hand, was addressed through a "cold case" that led players through a violent scenario from Adia's father's childhood and required them to learn about ciphers and mathematics. Thus, activities were designed to highlight the larger societal importance of STEM while at the same time engaging youth with realistic problems relevant to their lives and communities.

Youth were recruited to participate via flyers, online information provided to Chicago Public School teachers, and invitations at after-school programs. Youth were eligible if they were rising freshmen through graduating seniors. Enrollment occurred from April to mid-June of 2013. The summer program took place on campus Tuesdays through Thursdays with online activities on Mondays and activities that could be conducted either from home or on campus on Fridays. Youth received vouchers for transportation and lunch each day.

All players were invited to participate in study evaluation. Informed consent or parental consent and minor assent were obtained, primarily at a parent information session held the week prior to the start of the program. All players completed brief close-ended demographic surveys. The qualitative evaluation, conducted among a subset of players, consisted of focus groups and individual interviews carried out by an external science and mathematics curriculum research and evaluation group and the GCC Design Lab. The evaluation plan targeted the following three questions: to what extent do youth feel that their experience with *The Source* has affected their 21st century skills? To what extent do youth feel that their experience with *The Source* has affected their attitudes towards STEM in general, STEM self-efficacy, and STEM careers? What do team leaders and youth suggest for improving *The Source*? The evaluation is based on ten youth focus groups (n=48), ten youth interviews, and examination of game artifacts.

Data Analysis: Descriptive statistics of youth who participated in gameplay and evaluations were collected and managed using REDCap (Research Electronic Data Capture) electronic data capture tools, hosted at the University of Chicago (Harris et al., 2009). All focus groups and interviews were recorded on a digital audio recorder, and a verbatim transcript was produced by evaluation staff. These data were then cleaned of all personal identifiers and raw transcripts were given to the game lab research team. A preliminary codebook was developed based on the two conceptual frameworks and Chang's recommendations. To refine the codebook, two coders independently coded a subset of the transcripts and met to discuss and resolve disagreements with code applications. Code definitions were revised and inter-rater reliability improved after each meeting. All transcripts were then coded in Atlas.ti (Version 7.5.2) qualitative analysis software with the finalized codebook. Atlas.ti software was used to analyze codes. Matrices were developed to identify and summarize recurring patterns within each framework. Upon completion of the data analysis, the research team met to discuss and interpret the data and key findings; coding disagreements were resolved via discussion amongst the team. All procedures were approved by the Institutional Review Board of the University of Chicago.

Reception by and Feedback from Youth Players and Team Leaders

A total of 144 youth participated in The Source. The majority was African American (73%) or Latino (13%), male (63%), had home Internet access (95%), spoke English as their primary language (92%), and were eligible for free school lunch (60%). The mean age of participants was 15 years with a range of 13 to 18 years, and 63% were in the 9th and 10th grades. Forty-three youth participated in the focus groups and in-depth interviews. Focus group participants received $25 in gift cards as incentive to participate.

Student Feedback

Table 2 summarizes major themes identified in focus group and individual interviews.

Overall, youth rated *The Source* highly finding it enjoyable and engaging and helping them gain interest in STEM. As one focus group participant remarked, "I think that this was a brilliantly thought-out idea. .... Even though I'm not really a science, technology, engineering, math person, it kind of got me interested in it" Player Focus Group 7.

Learning through playing games was the central approach to the ARG. The actual games varied from scavenger hunts, to role play, to board games. For example, the ARG incorporated activities in which students role-played as STEM professionals, applying STEM knowledge and skills to actual job contexts. The GCC Design Lab created a game board depicting the city of Chicago with an overlay of hexagons, designing different "Hexacago" games that were played throughout the summer. One youth excitedly described how interactive activities got him interested:

They have…different jobs incorporated into our games. They had a chemistry game where they were like, this is a hydrogen atom, all of these atoms, which was interesting. And then engineering—they're constantly… talking about how engineers think. We had to make the card game, or we play these *Hexacago* games where we have to build cities and houses and we have to be careful about the cities and subways and how people would interact and where they would go, which is interesting. Player Interview 5

Youth also remarked on honing their problem-solving skills because games required strategy and multiple solutions. In the words of one player:

> "A lot of the stuff that we did required not just thinking about it in a certain way, but you had to think about it from different perspectives" Player Focus Group 8

Or as another said,

> "It has me thinking more than anything because I can't really focus on one thing because most things have more than one component to it. I have to think about all of the possibilities instead of just deciding on one possibility that I think" Player Interview 3.

The games themselves were educational but also fostered relationships and interactions with peers and adults. The research provided evidence that interacting with people working in STEM professions may have led to a more positive impression of STEM disciplines. Here, one young woman described her initial view of engineering as an unwelcoming field for women. Yet her experience during one professional's robotics demonstration made her question her views on gender stereotypes in STEM fields. The following quotation describes how activities helped youth imagine themselves in STEM careers:

"I guess I just think it's a masculine job. Like…architects,

Highlights, components noted as important	Interest building activities, Fostering relationships with peers and adults Imagining STEM Careers, Mentors, Importance of collaboration and peer-to-peer learning
Areas for Improvement	Clarity of learning objectives and connections between activities
	Authenticity of storyline (e.g., consistency/believability of characters and plot elements)
Lessons learned, unexpected findings	ARG most effective for broad exposure rather than in-depth learning
	Desired improvements including opportunities for youth to contribute their own ideas

Table 2. Summary of The Source Reception and Feedback

engineering, building up machines… I remember when we had [a] professional visiting, and he was teaching us about how he made robots, and how it was mostly girls in the room, and how it was the guys who weren't caring and it was the girls who are interested. And he was like, 'Girls, if you're interested, you should come to the engineer fair, because girls are really wanted.' I never knew that" Player Interview 5.

Youth strongly praised the inclusion of mentors in *The Source*. The mentors were near the youth in age as they were college and graduate students. One youth commented on the benefits of young mentors: "It's good, because they're not too much older than us, so it's kind of like working with another one of us, in a sense" Player Interview 4. One participant described the mentors as sources of inspiration and guidance for thinking about college. While mentors were not specifically instructed to address issues of college readiness, college preparation was clearly an area of discussion:

"And also you have the mentors that have had the full experience of college. When we first came here and our mentors asked us the things we wanted to do in college and what we wanted to study and stuff like that, and they gave us some sort of advice." Player Focus Group 4

In addition to learning from mentors, youth also appreciated learning from and interacting with their peers. A common theme was that school rarely required them to work on collaborative projects. Yet, as collaboration is key to STEM disciplines, it was a core component of every activity. One youth described learning the value of peer collaboration:

"I like working by myself a lot when I'm at school because I don't have any distractions or anything. But now it's good to get help from others when you don't know what to do. And I mean, I like communicating with other people and things like that" Player Interview 7.

A final program highlight was the role of technology in the game activities and Friday skill-building sessions. Articulating a view endorsed by many, one focus group explicitly recommended, "More tech stuff. Stuff where we're working on the computer more" Player Focus Group 3.

Areas for Improvement

There were many lessons learned and things that could be improved about the program. While some youth became very engrossed in the tale of Adia and her friends, others critiqued the narrative approach. They questioned the authenticity of Adia's storyline, which they felt could have been clearer and more relatable. One focus group participant elaborated upon the need for coherence and believability among the characters and plot elements:

"I just feel that for this to have been her story, it's too inconsistent…we're doing all this to help her, but her story just keeps changing…I would prefer standing in person and talking to us in person before you just send a webcam. If I'm about to help you and we're about to help each other, I feel like we need to meet each other, get situated, and know how to come and go…" Player Focus group 9.

Despite the critique, it should be noted that the player is not questioning the use of a narrative, only the way in which it was delivered.

In addition, the full-day program entailed frequent switching between activities. While some rated this pace as ideal for maintaining interest, others raised concerns about learning so many new rules for games and uncertainty about the scope and sequence of events. As one person said, "Some of the games were kind of like—it wasn't really clear. So some of the mentors would be like kind of confused about what we were supposed to do" Player Focus group 10. Similarly, while weeks were organized according to STEM topic, this logic and sequence was not always clear to youth. Thus, one focus group participant reflected, "It started off engineering, then it somehow got to STIs, and then it went to, what was it, Like, those don't correlate" Player focus group 5.

This concern points to a broader lesson concerning the use and implementation of ARGs. The program privileged exposure to a breadth of STEM topics over more focused in-depth study of any given topic. For example, one respondent noted, " that he was already fairly familiar with the learning content, and offered: "I think that the games—they taught you stuff, but it was really basic and something you would have known already." Player Focus Group 8. Complementing this observation, some students noted that the individualized Friday skill-building sessions were more conducive to in-depth investigation than the activities embedded in the ARG narrative:

"So I was going around like this, taking pictures of various ambulance and whatever. So that picture-taking moment was really fun, because then I knew that I had something to bring to the table and something that I could show my group, like, "Hey, I did this." Like, hey, that was cool." Player Interview 9.

A final area from improvement stems from one of the salient theme from the focus groups and interviews: youth enjoyed helping to design and develop the ARG. One young person said:

"I had to start talking to them, telling them ways to make these games better. And the fact that they were open and honest and wanted to hear the opinions of the game and what could be changed and how to make it better? …I could pitch my ideas and it was all open. But um, more getting into the program, we figured out how just flexible the games were. Like, they didn't mind us changing them, switching up, and making them better to where we liked to play them…" Player Focus Group 9.

In summary, the design team and research team spent months planning and preparing the ARG to ensure that each activity was well organized. Youth, in turn, thought they would prefer to have fewer activities and more opportunity to contribute their own ideas.

Discussion and Implications for Future Research

This project demonstrates that ARGs are flexible interventions for including key recommendations for promoting STEM interest and learning (i.e., Chang's [2002] recommendations). A five-week ARG played on a college campus in teams led by mentors and three youth protagonists was a new application of the form. ARGs were originally developed for marketing products, such as films and music, through mysterious narrative and entertaining challenges (Martin, Chatfield, & Thompson, 2006). One of the advantages of ARGs might be the variety of activities, allowing youth to approach the experience in different ways.

The games mediated rich human interactions for youth with both mentors and peers. For example, youth describe learning the value of peers as sources of information, or learning about college from program mentors. Mentoring has been found to be critical to young people's development. Yet a persistent dearth of volunteer mentors, particularly male mentors and mentors of color means that many young people lack these relationships (Rhodes, 2002). Some have suggested that mentoring relationships may be fragile due to the pattern of bringing together strangers from potentially different social contexts (Spencer et al. 2013). Perhaps relationships built through game-based learning allowed players to overcome some of these social barriers. Or, as in the example of the youth who spoke highly of the STEM professional who told her about girls and engineering, becoming engrossed in a hands-on activity helped her question her perception of gender norms.

The program accepted all interested students without strict enrollment criteria or required knowledge. To accommodate diverse learners, *The Source* privileged shared literacies, skills, problem-solving techniques, and modes of teamwork that cut across academic domains. In addition, STEM content was not delivered in discrete courses but in an integrated and interdisciplinary context, organized through a shared narrative, which previous research has shown to effectively create connections between STEM topics (Razak & Connolly, 2013).

Additional limitations must be noted. Given the many

activities, we were unable to ascertain which specific elements of the experience promoted learning or piqued STEM interest. Our findings suggest that young people approached the experience in different ways depending on their interest and abilities.

Conclusions

This ARG sparked interest in STEM for youth traditionally underrepresented in STEM fields. The ARG helped mediate relationships with peers and caring adults. Games and make believe also helped youth immerse themselves in science and technology. Longitudinal follow-up data will help to determine whether intensive, game-based summer exposure leads to continued STEM interest and supports academic achievement in formal learning settings.

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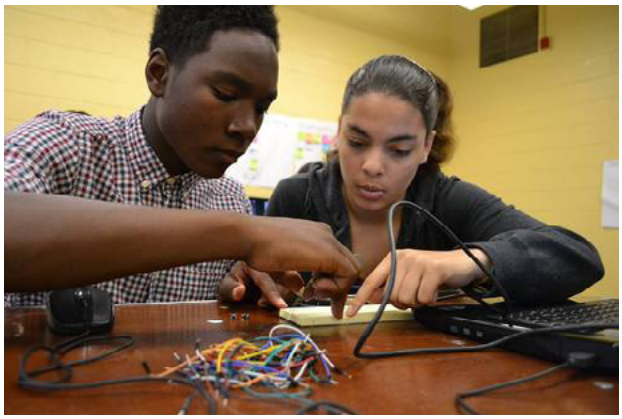

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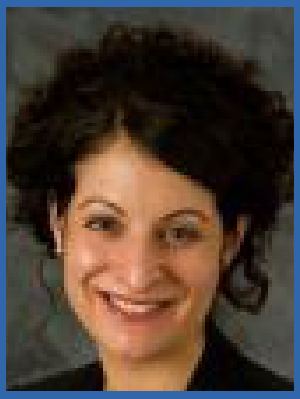

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