Understanding High School Students' STEM Identity, Game Play Motivations, and Game Preferences

Kathleen Jeremiassen
Amy Orange
Jana Willis
Michelle Peters
University of Houston-Clear Lake

Abstract: The purpose of this mixed methods study was to explore differences in students' STEM identities, game play motivations, and game preferences. The need to grow and support STEM education and careers in the United States is a widely held concern for those in leadership, industry, and education. A purposeful sample of 167 9th - 12th grade students from a southeastern Texas suburban school district participated in this study. Results indicated a significant relationship between gender and several game play motivations, as well as between gender and game preferences. Results also indicated a significant relationship between several game play motivations and STEM identities, as well as between several game preferences and STEM identities.

Introduction

The need to grow and support STEM education and careers in the United States is a widely held concern in leadership, industry, and education (Donors, 2017; Tang, 2015). Students' interest in STEM education and careers remain a concern for those in academia and industry. When examining the number of STEM courses taken or college degrees granted, females are taking a nearly equal number of STEM courses as males, they are enrolling in college at a greater rate than males, and females are holding more undergraduate STEM degrees than males (Beyer, 2014). Yet, when looking at STEM achievement from high school level courses through advanced college degrees, males still surpass females in the number of post-graduate degrees and exceed in areas of physical sciences such as physics, computer science, and engineering (Beyer, 2014; Virtanen, Räikkönen, & Ikonen, 2015). Currently, the rate of growth in computer science degrees is not matching the rate of the growing job market, an occupation where females represent less than 22.0% (Donors, 2017; Tang, 2015).

The gaming industry has seen the percentages of female developers more than double since 2009, according to an International Gaming Association survey revealing that females make up only 22.0% of game developers (Edwards, Weststar, Meloni, Pearce, & Legault, 2014). However, research finds that females are increasingly participating in game-play (Agosto, 2004; Ogletree & Drake, 2007; Shaw, 2012). Prior research has examined technology use, preferences, social structures, and self-identities, noting that study participants revealed differences again for males and females with respect to these constructs (Bekebrede, Warmelink, & Mayer, 2011; Fraser et al., 2014; Giammarco, Schneider, Carswell, & Knipe, 2015).

Members in the academic community continue to pursue an understanding of different factors influencing students' participation and achievement in STEM education. The problem is the need to determine new, important factors that may influence students' STEM identities and narrow the gender and race/ethnicity gap for STEM participation. Previous research has investigated how adolescents' science identity and science learning have relevance to gaming (Bricker & Bell, 2012; Fraser et al., 2014; Shaw, 2012). Studies have investigated parental influences and motivation for students' selection of STEM courses or undergraduate study choices in STEM, such as years of parental education, and utility-value (Choo, Sim, Liau,

Gentile, & Khoo, 2015; Rozek, Hyde, Svoboda, Hulleman, & Harackiewicz, 2015). Gender and race/ethnicity differences in STEM identities, game play motivations, and game preferences, as discussed in the literature review, may provide an understanding of the different factors contributing to the gaps in participation.

Research practitioners have sought and recognized connections between STEM and gaming constructs (Bricker & Bell, 2012; Fraser et al., 2014; Giammarco et al., 2015). Understanding self-identity, and self-concepts with respect to gender and race/ethnicity are recurring research topics (Bricker & Bell, 2012; Fraser et al., 2014). With current gender and race/ethnicity participation gaps in STEM education and STEM careers, it behooves society to take actions for change. The solution for closing this gap may be to step beyond present-day strategies and programming. Unfortunately, stereotypes remain in both private institutions and the public sector alike regarding STEM and gaming (Bertozzi, 2012; Vieira, 2014). Moreover, marketing efforts to attract females participating in STEM education/careers and in gaming have historically shown to be stereotypical in nature, undermining the very intent of attracting females (Bertozzi, 2012; Vieira, 2014).

Research Purpose & Questions

The purpose of this mixed methods study was to explore potential differences and relationships among students' STEM identities, game play motivations, and game preferences. The following research questions guided this study:

1. Is there a relationship between game preferences and students' STEM identities?
2. Is there a relationship between game play motivations and students' STEM identities?
3. How do students perceive, if at all, that their game play motivations, with respect to game preferences, relate to their STEM identity?

Methods

Participants

The study population consisted of 9th through 12th high school students from a large suburban school district, residing outside of a large metro area in southeastern Texas. This study utilized a purposeful sample of 167 students (80 males and 87 females) to participate in surveys. The campus utilized in this study had numerous opportunities for students to enroll in STEM courses, participate in STEM clubs and competitions, as well as selecting a STEM endorsed graduation plan. Participants were sought from a variety of course types and levels. In addition, 130 of the 167 students surveyed, participated in focus groups. Of these, 50 were male and 80 were female.

Instrumentation

Three instruments were used to collect data for the quantitative portion of this study. The survey items for STEM identities originated from questions within the *PRiSE Survey* (Hazari et al., 2010) and utilized by Hazari et al.'s (2010, 2013) works on identity. The *PRiSE Survey* asks participants to self-identity with specific science disciplines: (a) biology, (b) chemistry, and (c) physics.

The *Game Play Motivation Survey* items were first developed and utilized by Yee (2006a, 2006b); Yee's purpose was to empirically test Bartle's Player Types (Bartle, 1996, 2003,

2005) and create a quantitative instrument for measuring game play motivation. The three main components and correlating subcomponents for game play motivation are: (a) achievement (α = 0.74) comprising advancement, mechanics, and competition; (b) social (α = 0.77) comprising socializing, relationships, and teamwork; and (c) immersion (α = 0.75) comprising discovery, role-play, customization, and escapism.

Survey items measuring game preferences are based on the *National Survey of Game Users II* (Fraser et al., 2014). These authors selected 15 items based on gaming research which represent various game activity or genres, for example: solving puzzles and word games, first-person-shooter (FPS), role play in fantasy or role-playing environments. For this study, participants indicated if they like to play the given game activity or genre by simply checking one of the corresponding boxes (*Yes*) or (*No*).

Data Collection

Prior to participation, students provided their assent as well as their parent or guardian's consent. Classroom teachers monitored the survey collection process, which took approximately 15 minutes. Twenty-eight focus groups were conducted to gather participants' responses regarding their gaming play motivations, game preferences, and their STEM identities and for participants to make connections between their gaming practices and personal identities. Focus groups lasted approximately 30 minutes each and took place before or after school, or during a time allowed by the classroom teacher. Sessions were audio recorded and transcribed verbatim.

Data Analysis

To analyze the quantitative data, descriptive statistics such as percentages, frequencies, and cross-tabulations were calculated. In addition, a Chi-square test of Independence was conducted to determine if a relationship existed between students' game play motivations (or game preferences) and students' STEM identities and a Mann-Whitney U test was conducted to determine whether there was a difference between males and females in terms of game play motivations (or game preferences) and students' STEM identities. All quantitative variables were categorical in measurement. Qualitative data were analyzed using an inductive coding process. Data were sorted by similarities, dissimilarities, non-cases, and rival explanations. Responses were organized from codes into themes with attention on redundancy and saturation.

Results

Game Preferences and STEM Identities

Table 1 displays the findings for game preferences and STEM identities. Several game preferences or genres had a statistically significant relationship to STEM identities. Building *Cites or Environments* had a relationship to *Computer Science and Engineer Person. Simulate Taking Care of animals and Make Art* had relationships to *Biology Person. Change the Look of Something* had a relationship to *Physics and Math Person. Solve Puzzles or Word Challenges* had a relationship to *Math Person. Engage in Battles* had a relationship to *Physics, Technology, and Computer Science Person. First Person Shooter* had a relationship to *Physics, Technology, Computer Science, and Engineer Person. Role-play in Fantasy or Environments* had a relationship to *Technology and Computer Science Person. Simulate Cooking* had a relationship to *Biology and Computer Science Person. Conduct Scientific Investigations* had a relationship to *Biology, Physics, Technology, Computer Science, Engineer, and Math Person. Learn New Facts*

or Information had a relationship to *Physics, Technology, and Computer Science Person. Take Quizzes to Help Me with School* had a relationship to *Biology and Chemistry Person.* Game preferences that did not have a statistically significant relationship with gender were *Build Cities or Environments, Race with Obstacles and Challenges, Role Play in Fantasy or Role-Playing Environments, Conduct Scientific Investigations,* and *Learn New Facts or Information*

See Table 1

Game Play Motivations and STEM Identities

Table 2 displays the findings for game play motivations and STEM identities. Males reported a higher percentage for *Becoming Powerful, Acquiring Rare Items, Optimizing Your Character as Much as Possible, Competing with Other Players, Chatting with Other Players, Grouping with Other Players, and Keeping in Touch with Your Friends* compared to females. Game play motivations that did not have a statistically significant relationship with any STEM identities were *Chatting with Other Players*, *Being Part of a Guild,* and *Creating a Background Story* and *History for Your Character*. Several game play motivations were found to have a statistically significant relationship to STEM identities. *Becoming Powerful* had a relationship *to Chemistry, Physics, Technology, Computer Science, and Engineer Person. Acquiring Rare Items* had a relationship to *Technology and Computer Science Person. Optimizing Your character as Much as Possible* had a relationship to *Physics, Technology, and Computer Science Person. Competing with Other Players* had a relationship to *Chemistry, Physics, Technology, and Engineer Person. Grouping with Other Players* had a relationship to *Physics Person*. *Keeping in Touch with Your Friends* had a relationship to *Physics, Technology, Computer Science, and Engineer Person. Learning about Stories and Lore of the* World had a relationship to *Technology and Computer Science Person. Feeling Immersed in the World* had a relationship to *Technology and Computer Science Person. Exploring the World Just for the Sake of Exploring It* had a relationship to *Technology and Computer Science Person.* Game play motivations that did not have a statistically significant relationship with gender were *Being Part of a Guild, Learning about Stories and Lore of the World, Feeling Immersed in the World, Exploring the World Just for the Sake of Exploring It,* and *Creating a Background Story and History for Your Character*.

See Table 2

Student Perceptions

Some students were able to perceive a direct relationship between their gaming and STEM identities, more could articulate and indirect relationship, while others could not observe any relationship. Others found connections between their gaming and other identities, discipline areas, future career interests or how they saw their future selves. Several participants across the focus groups perceived either explicit or implicit relationships between their game play motivations and game preferences as linked to their STEM identities. For instance, Corey, who had a science identity and what he called “a little bit of engineering,” enjoyed RPGs as well as finding and creating things, such as “developing my own character”. He also connected his gaming to his future career, stating, “So, I feel like that, like, I guess, um, [gaming] helps me like science more, because of the chemistry and the, of all the physics that goes into building weapons and such”.

Types of thinking, focus, or mental challenge were related to participants' game choices and often connected to science preferred or self-identified by some participants. Participants discussed linear and non-linear thinking and games as well as how choices related to the entire game or system. George explained:

> I want to be a research scientist as well and I want to be a medical scientist when I grow up. In science, science can take a lot of different turns. It's not going to be, at the end of the day, it's not going to end in, it might not end in the same place as where you anticipated to end. So, that's why I like games where basically you can't really expect how it's [or] what's going to happen to you.

Problem solving was frequently discussed and related to personal goals, beating the game, or beating others by being faster or using a better strategy. However, participants also spoke about patience, perseverance, and tenacity to learn and stick with a game to reap the benefits, whether just finishing the objective, learning how to get to a goal multiple ways, or winning points and getting to the next level.

Finding objects, Easter eggs, or completing tasks was important to several participants and often seen as a benefit to leveling up or a sense of achievement. Management of resources collected was seen as an important skill, not just within the game, but for practice or future use and knowledge. Participants found value and real-life parallels to practical skills used games such as management and improving a team, communication, trading stock, decisions to purchase something based on statistics, having a counter argument, negotiating trade or issues in virtual worlds, or performing duties of a personal assistant. The virtual experience of building and creating things, from weapons, to structures, or even entire civilizations were appealing to many participants. Often, these tasks require accumulation of materials and skills, as well as decision making on how to best use these to the participants' advantage.

Several students claimed they felt accomplished when successfully moving through the levels and attaining a rank. Some felt personal satisfaction with this feat, where others enjoyed the peer recognition. Rachel shared, "[I like] finishing the objective, cause when you finish the objective you realize "Oh my gosh! I have reached another level and I can explore more into it." She added, "And leveling up is also a thing because you have more variety to, uh, such weapons and other characteristics of the game you never really got to get to."

Discussion

Educators must understand the critical connections between gaming and learning, and must seek ways to provide learning opportunities through gaming and immersive experiences where students may take on role-play and discovery, constructing new knowledge and collaborate with peers. Perceptions and mindset can only change through new experiences and exposure to alternative mindsets, based in research, which positively supports students' educational outcomes. The quantitative findings suggest associations between game play motivations and STEM constructs, and this study has theoretically provided a new factor that may be driving gender gaps in STEM that should not be overlooked by the educational field.

The focus group findings for perceived relationships between game play motivations, with respect to game preferences and STEM identities, revealed a need for educators to pay closer attention to students' perceptions and to learn how to better understand ways to utilize these perceptions to drive curriculum and instructional design. Professional development for digital game play, digital learning, and immersive learning, which is embedded into curriculum and instruction, should be provided to school administrators and teachers in order to change

perceptions and attitudes towards integrating gaming in the educational setting. Cognitive and learning theory, with respect to digital game play, must be further explored and the results disseminated into practitioners' toolkits.

Furthermore, school districts should be encouraged to develop a strategic plan for digital and game based learning, in coordination with the technology departments and digital-learning departments. Stakeholder education and corporate partnerships are necessary not only for buy-in and sponsorship, but to also to help determine short and long-term goals for technology implementation in the classroom.

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Table 1

Game Preferences Cross-tabulated with STEM Identities

Game Preferences	Bio %	Chem %	Pys %	Tech %	CS %	Eng %	Math %
1. Build Cities or Environments	48.4	35.8	42.1	78.9	44.2*	43.2*	58.9
2. Simulate Playing Sports	42.7	38.5	37.5	74.0	31.3	42.7	59.4
3. Simulate Taking Care of Animals	60.0*	36.4	34.5	70.9	40.0	36.4	52.7
4. Make Art	58.0*	39.1	36.2	75.4	39.1	44.9	55.1
5. Change the Look of Something …	56.7	35.0	36.7*	73.3	33.3	33.3	55.0*
6. Race with Obstacles and Challenges	49.6	35.4	39.4	75.6	36.2	44.9	57.5
7. Solve Puzzles or Word Challenges	50.0	39.8	36.7	71.9	34.4	43.8	60.2*
8. Engage in Battles…	50.0	35.0	40.8*	80.8*	44.2*	48.3	55.8
9. First Person Shooter Games (FPS)	49.5	35.0	40.8*	84.5*	46.6*	50.5*	54.4
10. Play, Make Music, or Dance	58.0	38.3	34.6	79.0	34.6	42.0	48.1
11. Role Play in Fantasy or Role-Playing Environ.	55.4	31.1	43.2	85.1*	48.6*	45.9	58.1
12. Simulate Cooking	59.3*	33.9	30.5	64.4	32.2*	30.5	49.2
13. Conduct Scientific Investigations	60.4*	45.3	50.9*	90.6*	56.6*	54.7*	66.0*
14. Learn New Facts or Information	53.6	41.7	46.4*	84.5*	45.2*	45.2	57.1
15. Take Quizzes to Help Me with School…	59.2*	47.9*	36.6	76.1	42.3	40.8	60.6

*Statistically significant relationship ($p < 0.05$).

Table 2

Game Play Motivations Cross-tabulated with STEM Identities

	Biology	Chemistry	Physics	Technology	Computer	Engineer	Math
Game Play Motivation	%	%	%	%	%	%	%
Becoming Powerful	51.8	41.2*	40.0*	81.2*	44.7*	54.1*	52.9
Acquiring Rare Items	54.9	36.6	43.7	83.1*	49.3*	49.3	53.5
Optimizing Your Character as Much as Possible	51.4	38.3	41.1*	82.2*	39.3*	47.7	57.0
Competing with Other Players	50.5	41.9*	49.5*	80.6*	41.9	48.4*	55.9
Chatting with Other Players	51.1	31.1	48.9	86.7	53.3	51.1	44.4
Being Part of a Guild	60.0	40.0	48.0	88.0	56.0	52.0	56.0
Grouping with Other Players	54.5	40.0	38.0*	80.0	41.8	47.3	52.7
Keeping in Touch with Your Friends	48.5	36.4	33.3*	75.8*	40.4*	44.4*	53.5
Learning about Stories & Lore of the World	56.9	35.3	39.2	86.3*	49.0*	47.1	56.9
Feeling Immersed in the World	56.5	43.5	44.9	79.7*	46.4*	43.5	55.1
Exploring the World Just for the Sake of Exploring It	51.4	39.2	41.9	73.0*	39.2*	41.9	54.1
Creating a Background Story and History for Your Character	54.5	38.2	36.4	72.7	41.8	49.1	47.3

*Statistically significant relationship ($p < 0.05$).