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Youth Identity, Science Learning and Gaming Experiences

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Prepared for:
Jodi Asbell-Clarke, PhD
Director, EdGE at TERC
TERC EdGE
2067 Massachusetts Avenue
Cambridge, MA 02140

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NewKnowledge is a non-profit research institute founded to pursue a deep understanding of how people engage with society's grand challenges. The organization works to expand understanding of how knowledge is acquired and acted upon in order to promote a strong democracy that enables all people to live to their greatest potential in harmony with the biosphere.

EXECUTIVE SUMMARY

The Educational Gaming Environments group (EdGE) at TERC is working to develop games that engage youth and promote STEM learning in and outside of the classroom. NewKnowledge is supporting this effort as the external independent evaluator for the project to explore the relationship between gaming and young people's science learning.

As the first phase of the research, NewKnowledge conducted a baseline context study as a front-end evaluation that explored the gaming/science learning relationship for youth in the US. The survey set out to answer a series of questions, including: What games engage youth? What is the nature of the relationship between games and science learning? To what extent does young people's engagement in gaming predict their understanding of the concept of the nature of science and their "science identity"? Does young people's choice of games relate to a particular perception of themselves as science thinkers and as gamers?

An online survey panel of 1,502 US teens provided a representative sample of youth across the country to explore these questions. The descriptive data suggests that:

In the few weeks prior to taking the study, most participants had played with some form of digital media, and mostly on computers rather than some other device;

- Most respondents claimed to like solving puzzles and word games for their digital gaming activities, and overall, teens prefer engagement in a wide range of games including those that involve sports, arts, and battles, as well as educational games;
- Most teens indicated that they prefer to play games on their own rather than with one or more other people;
- For most teens, their contributions as members of gaming groups are more important to them than their identity as gamers;
- Most teens reported believing they have a high competency in science activities, and that that competence is the most important factor in their self-evaluation as "science people;"
- Most teens acknowledged that science must address gaps in knowledge, and that science knowledge is tentative, testable, and must be revised over time;
- Teens with a limited understanding of the nature of science relative to those with a more developed understanding played more frequently in after-school programs and library contexts; and
- Games involving word puzzles, races, battles, and first-person shooters were most frequently played by groups defined based on the understanding of the nature of science (high or low), indicating broad appeal across teens.

Hierarchical regression analyses of the survey data revealed that:

- Enjoyment of games with problem-solving features and identifying as a gamer were the strongest predictors for teens' nature of science understanding;
- Teens' preference for games that embed science-related features and also competence in problem-solving games were also significant predictors of teens' understanding of the nature of science;
- For those who viewed their gaming groups in a positive light, a subgroup that played battle games understood the nature of science more than those who did not;
- For the group that identified strongly as gamers, those who played more race or puzzle games understood the nature of science more than the self-described gamers who did not play race or puzzle games;
- The strongest predictor of identity as a science person was a preference for games with science-related gaming features; enjoyment of games with problem-solving features as well as competence in them also predicted science identity;
- Valuing one's membership in gaming groups, identifying strongly as a gamer, and having a negative opinion of gaming groups were related to a stronger science identity; and
- Teens' identity as gamers was tied to their identity as a science person.

These data provided the basis for recommendations to consider when integrating science-concepts in a video gaming context:

- Games with word puzzles, races, battles, and first-person shooter could be targeted to engage those with a limited understanding of the nature of science in science concepts;
- For the subgroup who strongly consider themselves as gamers, games with word puzzles and races could be used to help them develop a better understanding of the nature of science; and
- To reach the subgroup who is proud of their gaming groups and communities, battle games might be the most uwful format to engage them in understanding the nature of science.

These data suggest that learning about science within a video-gaming context is related to a complex set of preferences, enjoyment, and perceived competence. While it is difficult to draw

causal connections from these findings, the results highlight the collaborative, social nature of video game play can be targeted to support science learning and help expand self-understanding of the perceptions of the self as a science thinker.

Social and personal factors relevant in a video-gaming world explained teens' science understanding and identity for nearly 25% a of the youth audience. It appears that science learning and game play can be connected through the gaming conext. It suggests that games that help build confidence in gaming may also support increased self-efficacy in youth as science thinkers and their sense of competence in real world situations.

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Introduction

Through the Leveling Up project, the Educational Game Environments group (EdGE) at TERC is studying how next-generation, cyber-enabled learning materials can radically transform young people's STEM learning experiences and enhance their abilities and interests in STEM fields. EdGE believes an answer to this question lies in the connection between free-choice digital games and classroom learning.

New Knowledge Organization Ltd. (NewKnoweldge) is supporting EdGE by conducting research into the transformative potential of transmedia gaming environments for high school STEM learning. The NewKnowledge study supports the work of EdGE, which is embarked on in Leveling Up, a project to research how social digital games commonly played outside of school can be used to support and measure players' standards-based high-school STEM learning. At the outset of this project, it was recognized that there is a deficit of information on teen media consumption and gaming choices in relation to their science interest, self-perception, and acumen. There is also insufficient understanding of who might choose to play games and why they might find some games particularly engaging. This baseline descriptive study sought to remedy both of those deficits through a representative national survey of US youth about their sense of self as a science thinker, their sense of self as a gamer, their behavioral strivings, and what they find compelling about online gaming environments.

Leveling Up explored the world of youth social gaming as an important context for enhancing science learning. Players' practices within gaming environments often overlapped with well-regarded learning models, such as communities of practice. In social games, players sometimes work together to accomplish tasks. To address the extent to which this collaborative effort was perceived as valuable in the context of gamers' self-identity as a "science person." Therefore, this front-end research also explored youth perceptions of the role and desirability of collaboration in a gaming context, and youth perceptions of its contribution to their sense of self as science learners.

For this component of the evaluation, NewKnowledge surveyed 1,502 teens – a sample of the population that the TERC games target recruited through Qualtrics, an online survey software company – to understand their gaming preferences, habits, learning and identities related to science, as well as their evaluation of themselves as gamers.

Instrument Development

YOUTH GAME PLAYING AND HABITS AND PREFERENCES

The Pew Internet and American Life Project (Lenhart et al., 2008) data on teens' gaming preferences indicated that most American teens play five or more genres of games and that about half play more than eight genres. In addition, results suggested that frequency of game playing the day before was moderately high. While half indicated not playing video games the day before, most of those who did played for at least an hour. These Pew data suggests that game play represents a common out-of-school experience that includes not only school days but also holidays and vacation time. Considered together, that time commitment would seem to represent contact hours equivalent to 25% of the time devoted to in school learning and sufficient effort to suggest that many teens devote sufficient time to develop mastery of skills with at least a few game genres.

The Pew research also revealed that teenagers were often involved in game play spanning a range of genres such as rhythm-based games, puzzle/card games, sports games, and first-person shooter games. Given the apparent popularity of several different kinds of games that require different skills and expertise, it is conceivable that engagement in different game genres could produce important learning outcomes, including games that relate to learning science concepts. Unfortunately, many games purport to have a scientific basis yet frequently adopt rules within the game world that may reinforce common misconceptions about science principles, such as the role of gravity in a game like Angry Birds where eggs dropped from a flying bird following a direct vertical path to the ground rather than a parabolic arc that would be consistent with release of an object from a moving vehicle. Thus, an assessment of the types of games in which teens engaged in relation to the science learning opportunities is necessary to fully understand the extent to which gaming represents both a mediating and mitigating opportunity for advancing science literacy in teen life in the US.

Experience

There is emerging evidence that greater experience of video game play is related to greater development of spatial reasoning skills. For example, Greenfield, Brannon, and Lohr (1994) tested the influence of a three-dimensional arcade video game on a mental paper-folding test. Structural equation modeling indicated that video game expertise over the long term (operationalized as a 10-week period) was related to students' improved skills on the mental paper-folding task. While acknowledging that a causal relationship between experience and science learning outcome may be difficult to document, this front-end assessment will incorporate experience as a critical predictor of teens' science outcomes related to game playing. The results from Greenfield et al. (1994) invite speculation about the implications of experience and skill at playing video games beyond that of spatial reasoning skills, to more specific science-oriented learning.

SCIENCE-RELATED GAME FEATURES

Recent research has, in fact, investigated the ways that video games can advance science learning (Squire, Barnett, Grant, & Higginbotham, 2004). Specifically, they found that features of a simulated game on electro-magnetism that actively involve the players presented them with tangible goals, as well as visual representations that facilitate problem-solving. They also helped students' understanding of complex science phenomena like electro-magnetism.

In fact, this research provides empirical support for Gee's (2007) speculation about game features and their ability to enhance science understanding. Gee describes four aspects of games that are relevant to positive learning outcomes: display of problem-solving or mastery; learning from failure to eventually win; competition as a social event; design features such as interactivity (players' ability to influence the progress of the game), sequencing (clarity of the connections between early and later parts of the game); and roleplaying potential. Specifically for science learning, it has been suggested that games provide an arena where students' conceptions and misconceptions about particular science topics may be critically examined and applied to solve problems (Squire, et al., 2004). They highlight the vivid, interactive environments in which gamers can engage in learning, environments that bring to life abstract concepts and ideas that are embedded in traditional curriculum:

These rich virtual worlds are what make video games such powerful contexts for learning. In game worlds, learning no longer means confronting words and symbols that are separated from the things those words and symbols refer to. The inverse square law of gravitational attraction is no longer something to be understood solely through an equation. Instead, students can gain virtual experience walking in a world with a mass smaller than that of Earth or they can plan manned space flights — a task that requires understanding the changing effects of gravitational forces in different parts of the solar system.

The authors thus theorize that the active involvement elicited by video games, the goals presented, and the visual representations of complex science concepts may be related to science learning. Although the relationship between science learning and most of the

items above has not been empirically tested, their link is conceivable and is thus of interest to this study.

However, as Squire (2010) points out, despite the recognition of video games as an effective instructional tool, the exact mechanisms by which they impart learning remain to be explored. This front-end study of teenagers' video game habits attempts to do that by incorporating Gee's theory of game features that can potentially translate to science learning.

TRANSFER IMPACT OF GAMING

That video games have the potential to connect abstract ideas and concepts to the real world has been recognized recently, as discussed by Michael Levine, executive director of The Joan Ganz Cooney Center at Sesame Workshop:

Educational video games, handheld devices and media production tools can allow young students to see how complex language and other symbol systems attach to the world.

Thus, this study also assesses how participants conceptualize the relationship between the games that they play and the non-virtual world they live in. The connection to the real world is explored both in how games do or do not comply with rules of the real world, as well as the effects on participants of their game play.

Science Understanding

Rather than assess students' baseline level of science learning through evaluating their grasp of specific science concepts, especially in the front-end survey, their science learning was assessed through an exploration of a more general understanding of the nature of science. An understanding of the levels of students' science learning was intended to inform the program developers during the initial stages of this project, as well as in subsequent rounds of evaluations (as discussed in the chapters below). Students' understanding of the nature of science followed the basic principles of science postulated by Schwartz, Lederman, and Crawford (2004). Specifically, their framework considers scientific knowledge to be grounded on a set of fundamental principles.

Scientific knowledge is tentative and subject to change, with reinterpretations forthcoming from new observations and inferences based on the natural world. Thus, it is based on a strong empirical foundation. Scientific knowledge is inherently subjective, not only because it is informed through the lens of existing theory, but also because of the unavoidable influence of values and personal agendas. In effect, such knowledge is built out of human imagination and inference, rendering it highly creative. Acknowledging the role of individual values also emphasizes how the socio-cultural aspects embedded in any society impacts how scientific research is conducted, interpreted, and accepted. Scientific knowledge is considered to take the form of laws and theories that describe relationships between observed or perceived natural phenomena. In effect, such knowledge depends on the inter-relationships among all these aspects. Such an understanding of science is captured in a measure developed by Tobin and McRobbie (1997) and was used in this study.

SOCIAL ASPECTS OF GAMING

This front-end study also acknowledged that engagement in video gaming can be a highly social activity. Specifically, video games can inculcate new cultural norms and practices, especially because the gaming environment facilitates shared learning and practices within groups (Shaffer, Squire, Halverson, & Gee, 2004). The acquisition of science concepts, whose understanding may be enhanced through gaming, may be especially facilitated when it occurs in collaboration among gamers. Thus, it is likely that the group dynamics of the gaming experience is an additional influential factor on cognitive outcomes such as students' learning (e.g., Squire, 2004). Peer-based learning by sharing strategies and collaborating on reaching desired game outcomes can be some of the ways gamers learn from each other in a virtual setting. As Shaffer et al., (2004) point out, such consideration of the social environment of game playing also has implications on other outcomes related to gamers' perceptions of themselves, and the identities they develop through their participation in a virtual world. Certainly, video games provide an arena for experiencing a range of social rewards , such as praise for one's game playing, belonging to a community of gamers, and validation and approval of one's actions (Olson, 2010). A study by Tarrant et al. (2001) indicates the social rewards that can emerge through game playing – teenaged boys rated "skill" in video games as the second most desirable characteristic (after being "fun") in their in-group of video gamers. Thus, video games may provide an ideal arena to elevate teen boys' social status.

The social implications of video gaming made it important to include an assessment of gamers' perceptions of the group of video gamers of which they are a part, as well as personal identities based on the same groups. Participants' responses to the social aspects of their gaming are intended to provide information on the tendency of gamers to participate collaboratively in video gaming communities.[1] An understanding of how youth find out about games they play was

[1] The social aspects of games can include social costs such as criticism and embarrassment; but was not explored in this study.

included as well, acknowledging that their social groups were also influential in their knowledge about games. For example, if participants are primarily finding out about games through friends, it may be useful to include a component of the game that allows for easy sharing among friends.

Data from the Pew Internet & American Life Project (Lenhart et al.,,2008) documented the social nature of game playing in contemporary times in a sample of approximately 1,100 teens ages 12 to 17. More than half (65%) of game-playing teens played with others in the same room, and 27% played with people with whom they've connected through the internet. Even though 82% did play games alone, 71% of this group also reported playing with others. Considering the large proportion of teens who play with others, whether closely in person or with mere acquaintances, these results strongly suggest that game playing may relate to developing social identities based on gaming groups and communities to which they belong. Because the Pew research is a few years old, the front-end study will test the extent to which this may have changed.

SCIENCE IDENTITY

Acknowledging the impact of games on personal identities also allows speculation about ways in which teens' science identities may be influenced. That the self can be conceptualized as a "science person," thus expanding one's idea of the self, has been documented by Beier, Miller, & Wang (2012). Moreover, these results in the context of a scientific game further add to the speculation about the possible selves that could be developed in an immersive, science-learning environment such as that which may be provided by video games.

A model of science identity developed by Carlone and Johnson (2007) was used to explore gamers' perceptions of themselves as science people. Acknowledging that identity is socially constructed, they theorize that its development occurs through interpersonal experiences, has impacts on learning, predicts behaviors and relates to one's understanding of the self. The authors consider three aspects of experiences with science – competence and mastery with science-related content and activities, social performance with science-related content when interacting with others, and recognition or validation from oneself and others as a science person. The front-end study utilized a slightly modified version that focused more on validation by the self and others, and less on the use of science material to inform others.

Methods

This study deployed a quantitative survey to explore US teens' involvement with experiences and interest in digital gaming, science learning and science identity. The research team sent requests to parents to give consent for their child, a potential teen participant between the ages of 14 and 18, to complete a survey through the Qualtrics survey site. Next, these parents either sent the survey URL to their child or asked him/her to complete the survey as linked from the email. The beginning of the survey was designed to prevent non-teens from taking the survey (see Participants section, below).

PARTICIPANTS

A representative sample of 1,502 teenagers from across the US was purchased and recruited through Qualtrics, an online survey panel supplier. To prevent non-teens from taking the survey, first participants were asked to confirm they were between the ages of 14 and 18, then two demographic questions about gender and where the person lived were asked. The third demographic question asked about the year they were born, but this question had a time limit—thus, if someone could not quickly identify the year they were born in, they were timed out of the survey. Age groups were capped so after 375 participants said they were born in a certain year, no more participants from that year would be accepted data.

INSTRUMENTS

The Qualtrics survey asked about teens' video game habits, preferences, and competencies. With the acknowledgement of the social nature of video gaming, a major focus was on their perceptions of the community of gamers and their interactions within that group. In addition, some of the speculations from the literature on science learning in a gaming environment were also explored.

Open-ended questions sought to identify particular games that teens play. Teens were prompted to answer questions about how they feel about science, how they perceive themselves in a community of game players, and how effective they are with games with science-learning potential.

General gaming habits

Two sets of questions asked about the frequency of teens' engagement in video game play, where the game play occurs, and the platforms they used. The first set comprised eight items and asked teens to indicate all the platforms (such as cell phones, consoles, computers, etc.) they had used to play games in the previous few weeks. An option to indicate that they had not played any was also included.

Another set was included to understand more about platforms. Game developers may be able to use this information to help determine the most appropriate platforms to focus on in future games.

The second set asked about the frequency of game playing in seven general locations, with items to be rated on a Likert scale ranging from 1 (*Daily*) to 7 (*Never*). These items were included to get a sense of typical arenas for teen video game playing, such as home, school, and friends' homes.

Game activities

The types of games teens play were assessed with a set of 15 game types. The list of game types was developed based on existing taxonomies, although they were expanded to include more game categories based on previous research (Lenhart et al., 2008; Phan, 2011). Teens were asked to indicate the types of games they liked with a dichotomous variable coded 1 (if they checked it) or 0 (If they did not) from a list that encompassed those that related to science learning (e.g., building cities or conducting scientific investigations), or those that involved overcoming physical (e.g. racing), or mental (e.g. word puzzles) challenges.

Experience

Teens' level of experience with games was assessed with items ranging from 1 (*Professional*), 2 (*Expert/Pro*), 3 *(Intermediate*), 4 (*Amateur*), to 5 (*Beginner*). Participants were asked to indicate their skill level by choosing one of the five options.

Knowledge of games

The sources through which teens learn about games were examined with seven options that included their social circles (such as family and friends), as well as more media-based ones (such as websites and TV). There was an option to indicate other sources not captured by the first six. These items were also intended to explore the extent to which learning about games occurs socially. Participants could choose all the ways in which they learned about games, captured by a dichotomous variable coded 1 (if they checked it) or 0 (If they did not).

Social nature of video game play

The extent to which teens liked playing games with others was assessed with a set of four items that asked about playing on their own, playing with others in the same room and playing with others online. Participants were again asked to pick all the options that they liked, measured with a dichotomous variable similar to the ones described earlier.

Involvement in the gaming community

Another assessment of teens' social interaction within their gaming communities included two items asking about their engagement in reading blogs about gaming as well as their contribution to content on the blogs and online forums. Participants were asked to rate these items on a seven-point Likert scale ranging from 1 (*Strongly disagree*) to 7 (*Strongly agree*).

Collective self-esteem

Acknowledging the potential positive impacts of video games on perceptions of the self, it was deemed important to assess the extent to which one's involvement with the community of video gamers influenced evaluations of the self. To assess this construct specifically, the Collective Self-Esteem scale (Luhtanen & Crocker, 1992) assessing individuals' positive self-evaluations based on group memberships was included in the Qualtrics survey. The 16-item scale comprised four subscales assessing evaluations from their close affiliation with groups (membership), evaluation of the groups' status based on their personal perception (private), evaluation of the groups' status based on their perception of others' assessment (public), and the extent to which group membership is important to their self-concept (identity). Participants were asked to rate these items on a seven-point Likert scale ranging from 1 (*Strongly disagree*) to 7 (*Strongly agree*).

The extent to which collective self-esteem from gaming groups was related to science learning and their identities as science persons was of particular interest in this front-end study.

Enjoyment of science related video game features

A set of 14 items assessed the extent to which teens enjoyed video game features that facilitated science learning. These items were based on game features theorized to facilitate learning, including science learning (Gee, 2007). These aspects included those that necessitated problem-solving or mastery, learning from failure to eventually win, competition as a social event, and design features that enabled impacting the progress of the game, connecting early and later parts of the game, and roleplaying potential. An additional item about aspects of games that had applications for real life was also included. Participants were asked to rate these items on a three-point Likert scale ranging from 1 (*Not very much*) to 2 (*A little*) to 3 (*A lot*). Participants also had an option to indicate "I don't know" if certain game features were not applicable. It was expected that greater enjoyment with some of these features would relate to greater understanding of science or a stronger science identity.

Similar to the previous set, four other items assessed teens' preference for games with science learning potential according to Gee's (2007) theory. These items were rated on a scale ranging from 1 (*Strongly disagree*) to 5 (*Strongly agree*), and assessed teens' preference for games where they get a chance to figure out game rules, use a demo or tutorial, or use trial-and-error methods to accomplish game tasks. In addition, one item asked about their perceived competence with games that involve problem-solving. Apart from allowing testing of a slightly different measure of preference with the first four items, the fifth about competence in problem-solving specifically tested how competence in a science-related gaming feature related to science learning and science identity.

Applications of games to real life

In these questions the study aimed to gain a better understanding of how participants conceptualized the relationship between the games they play and the real world. The connection to the real world is explored both in how games do or do not comply with rules of the real world, as well as the perceived impact the participant experiences from game play.

A series of three other items asked about teens' experience of game playing as well, probing the extent to which games are relaxing during and after playing, as well as boredom from accomplishing game tasks quickly.

All these items were rated on a seven-point Likert scale ranging from 1 (*Strongly disagree*) to 7 (*Strongly agree*).

Understanding the nature of science

Items to assess the representative sample's understanding of the nature of science were included for a baseline measurement of how they are thinking about science. Knowing about the levels of science learning students exhibit was not only intended to inform the program developers during the initial stages of this project, but also the analysis of subsequent rounds of evaluations. Although the latter will be conducted after participation in the online games, students' understanding of the nature of science will be better understood in the context of baseline measures of the population. The items included are selected and modified from the ones used by Tobin and McRobbie (1997) in their study with an Australian high school group. The items have been modified to use less jargon and align them with the rest of survey items geared towards the target group of student video gamers. The items were rated on a five-point Likert scale ranging from 1 (*Strongly disagree*) to 5 (*Strongly agree*).

Science identity

A measure of teens' science identity with 14 items was developed based on Carlone and Johnson's (2007) model. Three aspects of science identity were assessed in the study – competence with science-related content knowledge (e.g., *I am successful at science-related activities*), the importance of science identity to the self (e.g., *Doing science-related activities is important to who I am*), and the social validation of this identity from important people in the teens' lives (e.g., *It is important that others see me as a science person*). All the items were rated on a five-point Likert scale ranging from 1 (*Strongly disagree*) to 5 (*Strongly agree*).

Open-ended questions

A set of four open-ended questions assessed the games teens played most recently, the game sites they visit, their favorite game, and what they liked most about their favorite game.

While the first three items (about games played most recently, game sites visited, and their favorite game) were assessed primarily by documenting frequencies, a comprehensive qualitative analysis was conducted to explore students' explanations of why a particular game was their favorite.

An automatic content analysis software, a recent tool for qualitative research, Leximancer, was used to analyze the open-ended narratives students provided. This software based in natural language processing conducts automatic content analysis of text to uncover themes from the connections between words used. By ranking words based on their frequencies and then assessing their co-occurrence with other words generated specific "concepts" for each set of words that were semantically close. Additionally, these concepts were organized into broader "themes" that depict the data in ways that allowed knowledge building based on these responses. One of the highlights of Leximancer was that it displayed the analyzed data as a visual representation of the most important concepts organized into the themes for more effective data interpretation.

A NewKnowledge researcher used Leximancer for a visualization of the thematic analysis of the survey question "What do you like about your favorite game?" using both automated and user-defined settings. According to Smith and Humphreys (2006), Leximancer offers the flexibility to tailor analysis depending upon the specific research questions, as long as they are part of a deliberate analysis strategy that can be justified. For example, the total number of automatically selected concepts can be increased to extract more specific concepts from the low ranked words. Words that occur frequently and co-occur with others, without contributing to semantic value may also be removed from analysis. Concepts can also be defined manually based on criteria theoretically relevant to the research question.

Hence, in the analysis reported here, the rationale for each customized manipulation is explained in detail. This is intended to enable evaluating the validity of our strategy and ensure it is grounded in evidence gathered through an accepted methodological framework, and not anecdotal.

For this study, the concepts were generated automatically without explicitly including the ones that had low initial ranks. Concepts identified by the automatic process were utilized for final analysis and interpretation. Acknowledging the innovative nature of this research, and the fact that the research question explored with Leximancer had received limited research attention, NewKnowledge chose to let the software surface the themes depicted in the data.

Multiple iterations of the data analysis were conducted to understand the themes that described teens' responses. To start this process, all the responses were reviewed. This was followed by use of the automated settings to uncover concepts that were deemed relevant by the software. Following this, the researcher adapted the setting to remove some concepts which despite occurring multiple times were actually not relevant when explaining why a game is favorite.

After the first automated run of the open-ended data without any manipulation by the researchers, Leximancer generated a set of concepts that were reviewed closely by the researcher. In this phase, one set of concepts and themes were built from words such as "gameplay", "gaming", and "playing"; however, these words though functional in the text, were considered less meaningful for creating concepts since they did not add value to reasons for considering a game as a favorite. Owing to their low semantic value for the analysis, they were added to a stop list to be removed for the analysis (Smith & Humphreys, 2006). Other words were similarly manipulated in several rounds of testing (see Table 1). For example, some words in the stop list were indicated to be "evidence" so that they would be included in the analysis to identify concepts based on their co-occurrence with other words, but would not individually contribute to a concept.

Table 1. Concepts included in Leximancer iterations and manipulations

Second Iteration	
Added to Stop List	
Able	*Line*
Gameplay	*Online*
	Playing
Added to Stop List	
Against	*Games*
game	*gaming*
Removed Concepts	
World	*Played*

After the first iteration, person, people, and others were merged into one concept, however others was not always used in reference to other people, rather they were in reference to other games, or another entity. Therefore for the subsequent iteration, others was removed from the concept that included people and person. Additionally, two compound concepts were formed and labeled story line and real life.

The third iteration with themes represented at 43% produced a concept map with seven themes. When set to 100%, all the concepts evident in the data can be displayed. However, by sliding the scrollbar to the left and then scrolling slowly to the right will surface the most central concepts in the data in order (Leximancer Manual, 4, 2011). The concepts displayed at 43% represented the most meaningful set that could be interpreted within the context of the current study.

Given the automatic number of concepts produced by the program three of the themes only had one concept in its circle (Table 2).

Table 2. Leximancer themes and concepts, showing % connectivity or first degree connections

Theme: Graphics and Story		100%
graphics	*level*	*story*
love	*different*	*skill*
multiplayer	*time*	*person*
Theme: Relation to Reality		74%
characters	*real*	*life*
real and life	*build*	*create*
strategy	*everything*	
Theme: Fun		62%
fun	*challenging*	*friends*
easy		
Theme: Social Aspects of Gaming		25%
people	*awesome*	*missions*
shooting		
Theme: Action		7%
Action		
Theme: Music and Motion		2%
music	*other*	
Theme: Puzzles		1%
Puzzles		

Results

Demographics

According to the survey responses, 44.4% of participants identified as male (n= 667) and 55.6% identified as female (n= 835). Almost half of the participants indicated they lived in a suburban area (46.5%, n= 698), while 22.2% of respondents indicated living in a rural area and 31.4% participants indicated living in an urban area. A quarter of the participants (n=375) were born in 1994, making most of them 18, assuming that most people in 1994 were born after March (Figure 1).

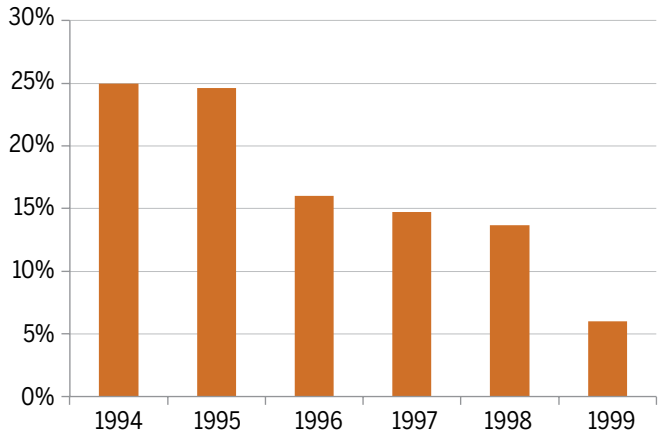

Figure 1: Distribution of respondents by birth year (N=1502)

Gaming Habits

Teens' responses to questions about their gaming habits indicated that only 6.1% had not played a game "in the past few weeks" (see Figure 2). The remaining youth responded playing on all seven different types of digital media listed, where the majority of game play took place on a console, such as XBox (n= 1077), computer (n= 1009) or cell phone (n= 942). The average respondent reported playing on 2.86 different systems (SD= 1.36).

Teens indicated playing games most often at home (daily, 57.3%, n= 861; two to three times a week, 21.1%, n= 317). The next most frequent location students played games was at school during free time, in which 18% of students said they play daily and an additional 16.5% said they played at least two to three times a week (Figure 3). The distribution of frequency in which teens played digital games at friends' houses was mostly evenly distributed between 8.6% to 19.7%, where 20.8% of respondents said they never played at friends' homes.

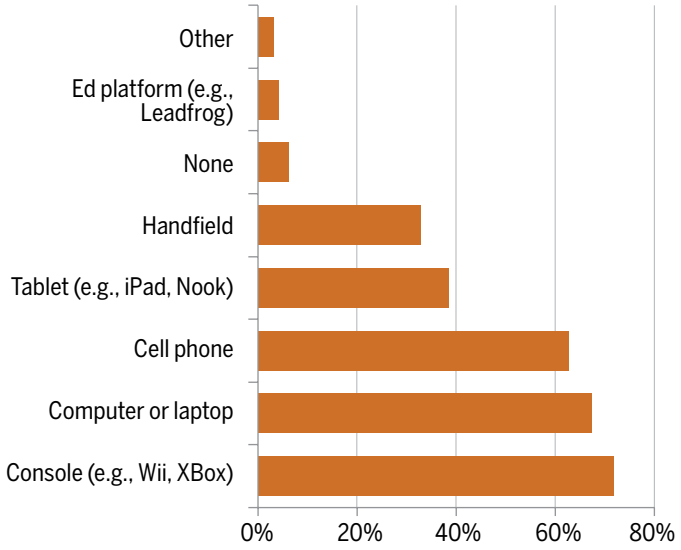

Figure 2: Platforms for game play (multiple options possible), including non-gaming respondents.

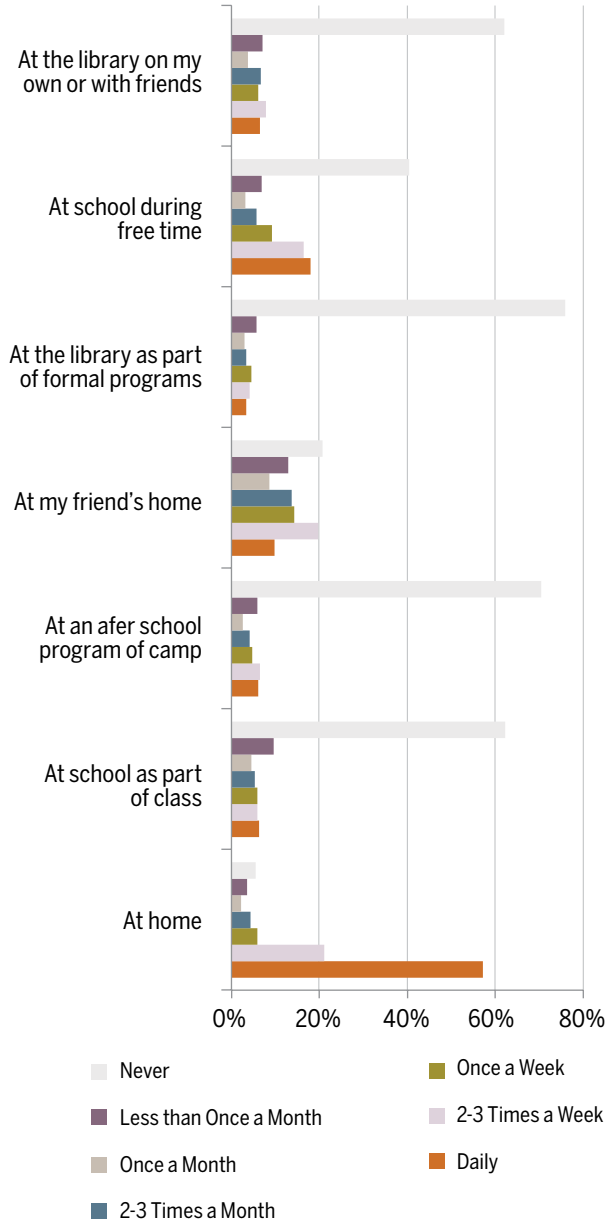

Figure 3: Venue choices for those who play games daily

Gaming Preferences

Teens could identify up to 15 digital gaming activities that they like to do, but the average teen reported liking 5.12 types of activities (SD= 2.94) Around half of teens reported liking, solving puzzles and word games (52.3%), racing with obstacles and challenges (51.4%), playing or making music and dancing (48.4%), engaging in battles (47.9%), and first person shooter games (45.7%) (N= 1502, Figure 4).

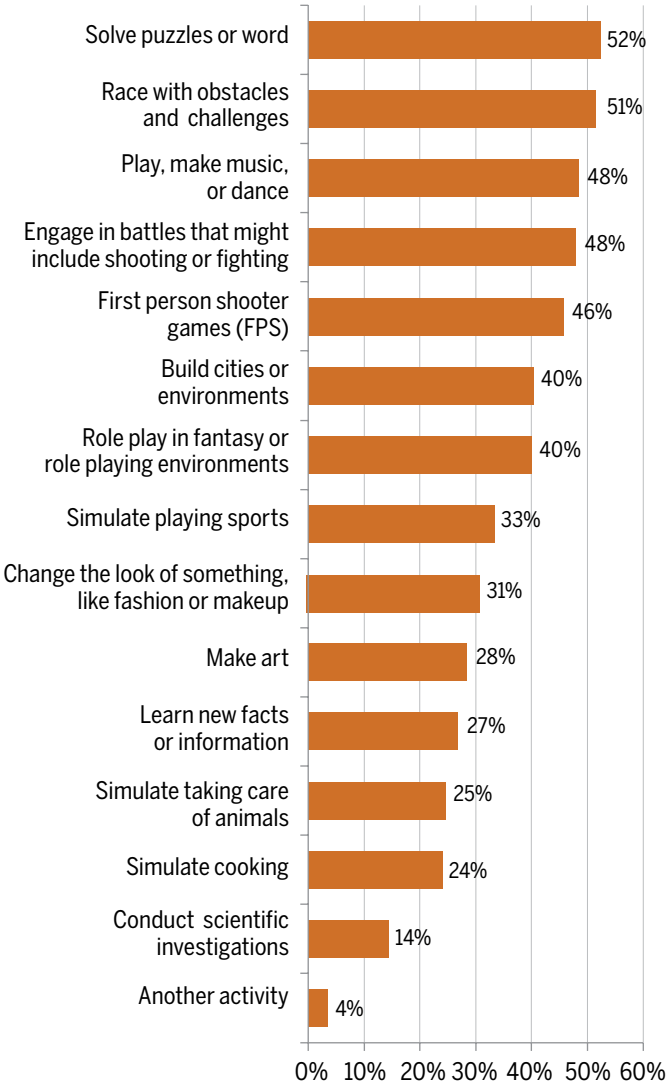

Figure 4: Game preferences

"First person shooter [FPS]" and "engaging in battles" were the most strongly correlated of the 15 digital activities, $r = .485$, $p < .001$. The items that shared Pearson Correlations above .350, were intuitive, such as "taking care of animals" being correlated to "changing the look of something" ($r = .354$, $p < .001$) as well as the latter's correlation to "make art" ($r = .385$, p $p < .001$). While these stereotypically feminine activities were among the higher correlated items, so too were the stereotypically masculine activities where "playing sports" was significantly correlated to "racing, obstacles or challenges" ($r = .248$, $p < .001$) and participating in "battle"-like activities ($r = .208$, $p < .001$).

Only 14.4% of teens reported playing games that feature scientific investigations, with its strongest correlation being with activities that involved "learning" ($r = .284$, $p < .001$).

When teens were prompted to provide open-ended feedback on three to four games "they have played in the last three weeks," the most-played game was the Call of Duty series (see Appendix C, question 7). The Sims, Halo, Mario, and the Madden series games were the next most frequently reported as being played. Similarly, when asked to name their favorite game of all time, the Call of Duty series was the most frequently reported favorite game (Appendix C, question 10).

Almost half of teen respondents (48.4%, $n = 727$) considered their skill at gaming to be intermediate and almost a third of the respondents felt their gaming experience exceeded the intermediate level (Figure 5).

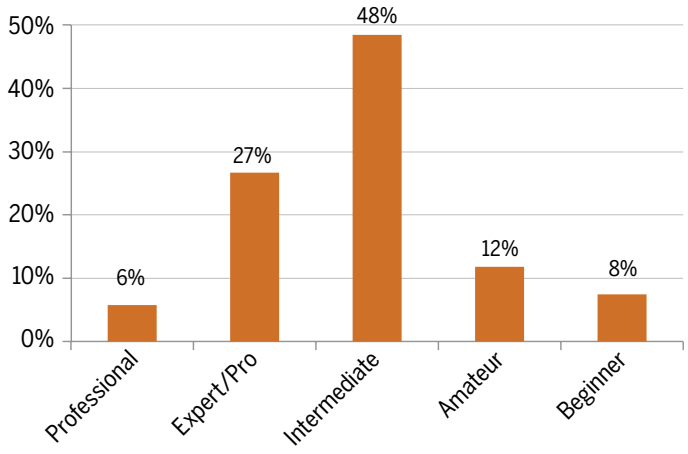

Figure 5: Self-perception of game skill level (N=1502)

SOCIAL ASPECTS OF GAMING

Gaming with others

The majority of teens (79.0%) reported liking to play games on their own ($n = 1186$). However, correlations indicated that teens who reported that they like to play games with their friends in the same room were also likely to report playing games online with people they know ($r = .346$, $p < .001$) and playing games online with people that they do not know ($r = .281$, $p < .001$). Similarly teens who reported playing games online with people they know are also likely to play games online with people they have never met ($r = .465$, $p < .001$). Thus, irrespective of their preference for playing with friends in person or online, teens seemed interested in playing online with acquaintances or even strangers. However, those who liked playing games on their own were less likely to play with friends in person, online, or with strangers online, as indicated by the weak correlations in Table 3.

Table 3. Pearson correlations for social aspects of gaming

I like to play games where I get to play. . .	1.	2.	3.	4.
1. with my friends in the same room ($n = 876$)	1	.35**	.28**	-.05*
2. online with people I know ($n = 829$)		1	.47**	-.08*
3. online with people I have never met ($n = 640$)			1	-.01
4. games on my own (n=1186)				1

Over three quarters of respondents (78.2%, n= 1175) found out about new games from friends (Figure 6) but the average respondent learned about new games from 2.55 sources, where 2 was the median and the mode (SD= 1.26). Almost half the respondents said they find out about new games from game sites (48.2%, $n = 729$) and approximately 42% of respondents looked to family members or TV. These results highlight the role of teens' social circles in their gaming activities, and show the influence of game sites, family members, and TV on their game choices. The four most frequently visited game sites in order of most frequent reports were Game Stop, IGN, Gamefly, and Game Spot (see Appendix C, Q9).

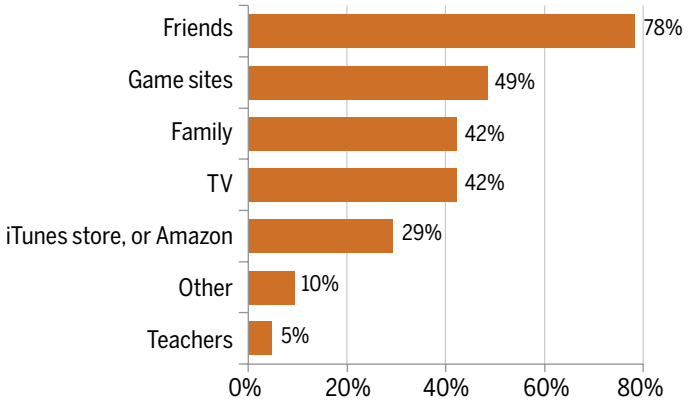

Figure 6: Source of information about games

COLLECTIVE GAMING SELF-ESTEEM

The collective self-esteem scale adapted to fit this National Gaming survey remained a reliable tool (16 items, α = .760). Most of the items in the scale were rated close to the midpoint of 4 (neither disagree nor agree) on a seven-point scale (Table 4), with the overall mean being 4.37 (*SD* = .45). Despite their middle range means, paired t-tests of each pair of subscales indicated differences between them. Differences were seen between all pairs of subscales, except between Membership and Private. It was evident that teens' personal identification with their gaming groups were the lowest compared to the other subscales (*M* = 3.71, *SD* = 1.02; Table 2). This indicates that although teens tend to think of themselves as successful gamers in the gaming community, this factor contributes least to their sense of self (or identity) as a gamer in other parts of their life.

Table 4. Collective gaming self-esteem

	M	*SD*	Mode
Membership	4.64	1.00	4
Private	4.65	0.92	4
Public	4.49	0.77	4
Identity	3.71	1.02	4

Note. * = p< .05, ** = p< .005

The relatively low importance ascribed to being identified as a gamer indicates that while teens do not think being a gamer is important to who they are as people, they apparently care about others' opinions of their gaming groups and even personally consider the groups to be positive. This was evident in correlations with the other subscales of the collective self–esteem. Even though the other three subscales were moderately correlated (between 0.61 and 0.64, $p < .001$) with each other, the identity subscale indicated weak correlations (from 0.08 to 0.11, $p < .001$), confirming that the Collective Self-esteem construct (citation?) is useful for assessing types of perceived social regard for gaming as a predictive variable in the study.

Table 5. Correlations in self-esteem subscales

	1.	2.	3.	4.
Membership	1	.644***	.606**	.078**
Private		1	.610**	.610**
Public			1	.030
Identity				1

** $p < .001$

Each of the subscales of collective gaming self-esteem were significantly correlated with at least one type of gaming device that teens game on with the exception of Leapfrog and other educational gaming systems. Although significant correlations were generally weak, the strongest correlations were between the subscale measures for membership ($r = .280$, $p < .001$), private regard ($r = .271$, $p < .001$), and public regard ($r = .220$, $p < .001$) with gaming consoles. Differences in the strengths of the correlations across the different subscales and gaming systems indicate that their gaming platform related to different aspects of their gaming communities.

Those who were more experienced with video games were also more likely to hold more positive evaluations of their gaming groups. However, those who felt gaming mattered to their identity indicated the weakest correlation with experience ($r = -0.141$, $p < .001$), while the strongest correlation for experience was $r = -0.316$, ($p < .001$), acknowledging their personal contribution to the groups (the correlations are negative because the most experience / professional was coded as 1 and the least experienced / beginner was coded as 5).

In concert, these results indicate that teens' perceptions of their gaming groups were fairly moderate, with the groups contributing relatively little to their personal identities, compared to their opinion of themselves as valuable members of gaming group or their personal and others' views of their groups. Even though the gaming consoles teens used were similar for different aspects of collective esteem, the correlations were especially more for those who valued

themselves as a gaming group member, compared to those who identified more strongly with gamers.

Science Identity

Fourteen statements included in the survey prompted teens to rate their agreements with science issues related to their identity as a science person (α = .959). These statements gauged the importance of science identity to themselves, science identity as a social validation, and their competence in science activities. The mean of identity as a science person was 3.20 (*SD*= .91). However, closer examination of the individual items provided a deeper understanding of how students identified as a science person. For example, only 38% of respondents agreed or strongly agreed that they "think of [themselves] as a science person" (Figure 7). Similarly only 33.3% agreed or strongly agreed that doing science-related activities were important to their identity. Contrasting with these are responses of 49.5% of teens who agreed that knowledge and skills in science helped them contribute to issues of importance to them.

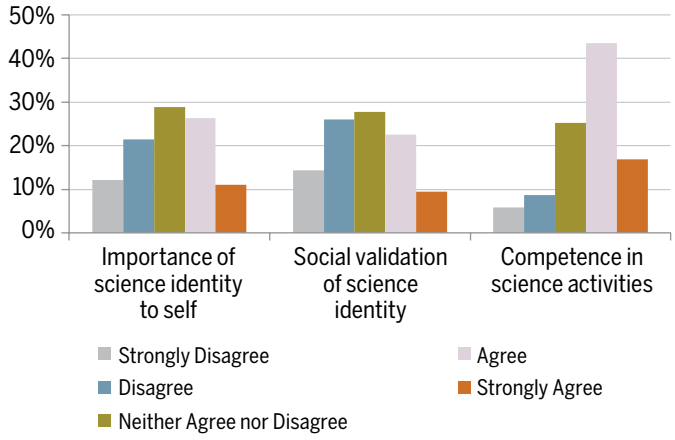

Figure 7: Identity as a science person subscale mean distribution

The three subscales of science identity were all significantly different from one another (see Appendix B). The average respondent reported believing they had a higher competency in science activities than an identity that was important to the self, the mean difference was -.47 (*SD*= .63, *n*= 1485) and the need for social validation of a science identity -.70 (*SD*= .79, *n*= 1477). The mean difference between the identity important to the self and social identity is .23 (*SD*= .50, *n*= 1482).

Nature of Science Understanding

The nature of science understanding measures was internally consistent (17 items, α = .843; see Table 6), with average responses having a moderate understanding of science (M= 3.73, SD= .50, n= 1502). Closer examination of the items indicated a more comprehensive understanding of teens' understanding of science.

Table 6. Nature of science understanding

	M	SD
*Scientific knowledge does not change with time	3.78	1.15
Scientific knowledge is subject to review and change	3.95	0.89
In developing areas of scientific knowledge, competing theories may be held for a long time	3.73	0.83
Science progresses by refining and replacing old theories with new ones	3.81	0.91
Today's science laws, theories and concepts may have to be changed in the face of new evidence	3.84	0.89
There are still many unresolved issues that need to be solved in science	4.16	0.88
Scientific truth changes with time	3.72	0.92
Scientists often disagree about scientific knowledge	3.78	0.92
*Scientific knowledge is always correct	3.57	1.04
*Once a law of science is discovered it should never need to be changed	3.63	1.06
*Scientific knowledge is the same throughout the world	3.38	1.08
Scientific knowledge is verified by experiments	3.86	0.85
Science is a search for truth	3.88	0.90
Scientific knowledge gets closer to the truth as time goes by	3.57	0.89
Scientific laws, theories and concepts are continually being tested	4.06	0.82
Scientific knowledge does not have to be repeatable to be accepted	2.72	1.09
*The evidence to support scientific knowledge need not be communicated to other scientists for their examination	3.33	1.21
Understanding the Nature Of Science	3.73	

Note. * represents reverse coded items for total mean.

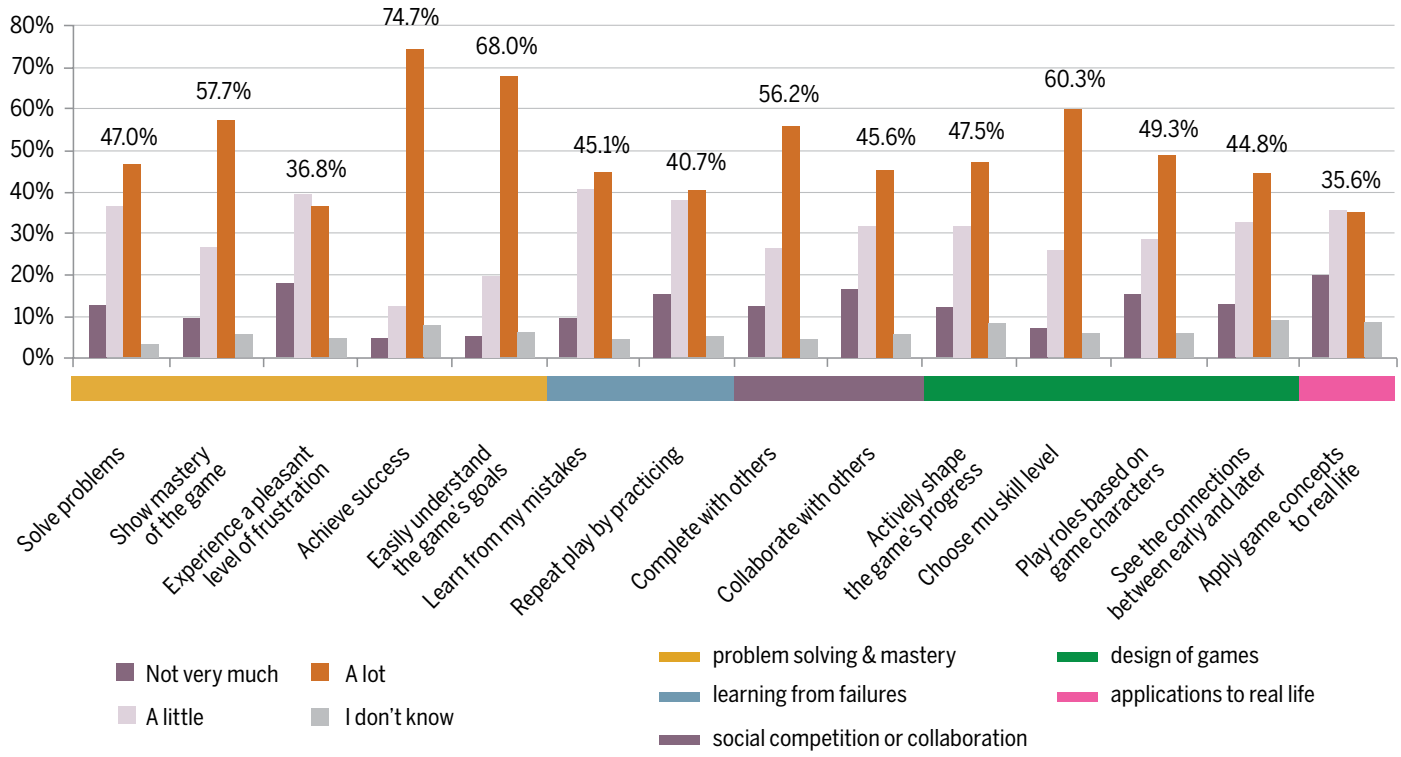

Figure 8: Aspects of gaming that facilitate types of science learning.

Teens indicated highest ratings for items that acknowledged the gaps in knowledge that science has to address, the tentative nature of science knowledge, its testability, and the need to revise it over time. The average youth respondent agreed that "there are still many unresolved issues that need to be solved in science" (M= 4.16, SD= .88) and "scientific laws, theories and concepts are continually being "tested" (M=4.06, SD= .82). In contrast, the lowest rated item indicated neutral ratings with a slight sway towards disagreement about scientific knowledge needing to be repeated to be acceptable (M= 2.72, SD= 1.09).

The survey prompted teens to share how much they enjoy different features of games that were based around five science concepts: problem solving and mastery (in Figure 8, orange items); learning from failures (blue); social competition or collaboration (purple); design of games (green); and applications to real life (rose). The measures of enjoyment of science features in games were highly internally consistent (14 items, α = .891). Teens were given the option to answer with "I don't know" but this was treated as missing data. Hence, the scale was measured on a three-point scale, with "not very much" (1), "a little" (2), and "a lot" (3).

Overall, teens most enjoyed the problem solving and mastery features of games (*M*= 2.49, *SD*= .44, *n*= 1478), where 74.7% of respondents reported that they like to "achieve success" "a lot" (*n*= 1122, see Figure 8). In a similar vein, 60.3% teens reported that they liked being able to "choose [their] skill level" (*M*= 2.56, *SD*= .64, *n*= 1409), a design feature that allows teens to succeed. The four gaming features that facilitate science learning were all significantly different from one another with the exception of design features of games and social aspects of gaming such as collaboration or competition (see Appendix B). Of the remaining three factors, teens reported liking, in declining order, design features (*M*= 2.42, *SD*= .54), social aspects of gaming (*M*= 2.39, *SD*= .66) and learning from mistakes (*M*= 2.32, *SD*= .58).

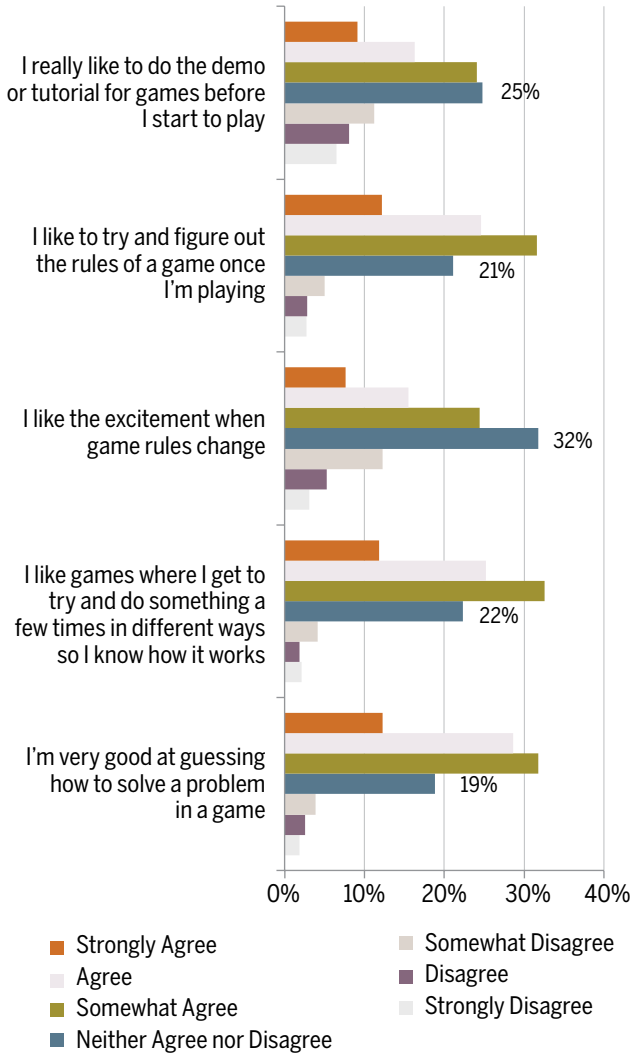

Figure 9: Gaming compentency and preferences.

Transfer of gaming to real life

Respondents were asked to rate their level of agreement with statements about how gaming may have applications to their real life (Figure 10). Teens' mean ratings indicated that they disagreed that games frustrated them when they don't follow rules of the real world (M= 3.49, SD= 1.58), and they seemed to be neutral about games' helping with school (M= 4.03, SD= 1.50), and their application to the real world (M= 3.87, SD= 1.61). More than a third of the respondents (41.5%) reported disagreeing with the statement "games have no connection to the real world" and just over a third (33.4%) agreed with the statement, leaving the remaining quarter neither agreeing nor disagreeing with the statement. Almost 40% of the national sample reported that what they learn through games has helped them in school (39.8%). Almost half the teens disagreed (46.4%) that they get frustrated by games that do not follow real world rules, and 28.0% acknowledged being impartial. Their knowledge of this difference may influence their ideas about gaming being applicable to real life.

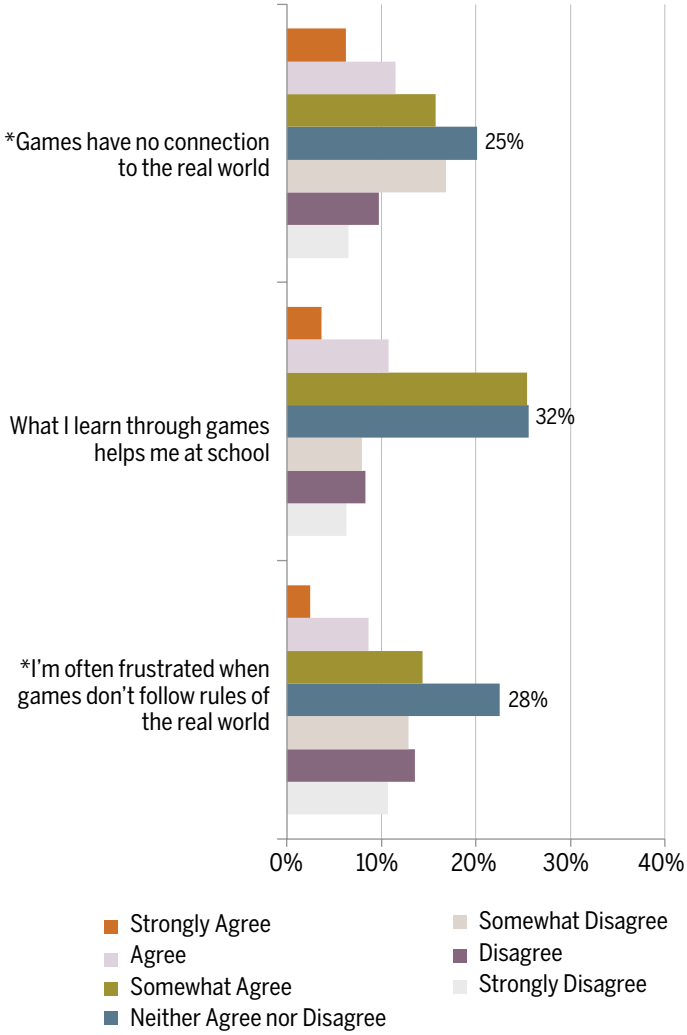

Figure 10: Agreement on the application of gaming to real life.
* represents reverse coded items.

Table 7. Regressions on Understanding the Nature of Science

	B	SE (B)	β	t	p
Suburb- Dummy Code	.082	.187	0.082	3.14**	0.002
Rural- Dummy Code	.097	.026	0.081	3.09**	0.002
Age	.014	.032	0.045	1.91	0.057
Gender	.085	.007	0.085	3.41**	0.001
Perceived gaming skill level	.036	0.025	0.067	2.50**	0.012
Collective gaming self-esteem					
- Membership	.061	0.015	0.123	3.60**	0.000
- Private	.090	0.017	0.166	4.79**	0.000
- Public	.049	0.019	0.075	2.40**	0.016
- Identity	-.095	0.012	-0.196	-8.05**	0.000
Competence with science related game features	.060	0.012	0.151	5.05**	0.005
Preference for science related game features	.002	0.015	0.004	.133	0.894
Enjoyment of science related game features					
- Problem solving and mastery	.240	0.037	0.212	6.54**	.000
- Learning from failures	-.037	0.025	-0.043	-1.51	.132
- Social aspects (competition or collaboration)	-.070	0.021	-0.092	-3.26**	.001
- Design features	-.010	0.029	-0.011	-0.35	.724
Application to real life	.065	0.013	0.121	4.89**	.000

Notes. * = p< .05, **= p< .005, R^2 = .267

Although 61.3% of teens reported feeling more relaxed when they play games, only 56.1% reported feeling relaxed after playing, where about a third (29.9%) of survey participants neither agreed or disagreed with these statements (*N*= 1502). Half of the survey participants did not contribute to gaming sites (*n*= 752) and about a quarter of participating teens (23.0%) neither agreed nor disagreed that they contribute to gaming sites. However, 41.1% reported reading gaming information sites, blogs, and forums (*n*= 628).

Understanding the nature of science

The final model in a regression analysis indicated the multiple variables that are significant predictors for teens with a high understanding of the nature of science, but all these predictors were weak at best. The strongest predictor among these in the regression was enjoyment of problem solving and mastery features of games (β = .21, p < .001) (Table 7). All subscales of collective gaming self-esteem were significant predictors of higher understanding of the nature of science. However, the identity subscale was a negative predictor, in that the less one identified as a gamer, the greater their understanding of science.

Based on these results, speculations can be made about the mechanisms through which these variables are related. For example, it is likely that a gamer identity is associated with aspects of video games that are related less to those that facilitate science learning compared to non-science-oriented ones. However, that their personal evaluations of video game groups and perceived value as members in these groups positively predicted science learning suggests that their involvement in the groups could potentially relate to science content, possibly contributing to their high evaluations of them.

Other significant positive predictors of science understanding were teens' competence of games that involve science features (β= .15, p < .001) and their acknowledgment that games can relate to real life (β= .12, p < .001). Thus, what these results suggest is that although teens' higher preference for games with science-learning potential

were related to their greater understanding of science, it seemed that it was enjoyment of specifically one type of science feature—problem solving—that was especially important for greater understanding of science.

Enjoyment of another science-related gaming feature - its social aspects (such as collaborations and competition) – was indicated to be a significant predictor of science understanding. In this case, a negative relationship was evident (β= -.09, p = .001). The implication is that the socially interactive features of video games are not necessarily facilitating involvement in science learning. Acknowledging that research and practice in science is inherently a social process, this feature was considered to indicate a positive relationship with science learning. Specifically, this was based on the supposition that online, collaborative efforts with peers geared towards science-oriented tasks could promote understandings of science. However, what the descriptive data and this regression analysis indicate is that while teens do enjoy the social aspects of games to a moderate extent, their peer interactions appear to offer less scope for science learning; hence it is likely that enjoyment of the social interaction through gaming involves enjoying the opportunity to play games with friends and be part of a gaming community. It should be noted that while it was speculated that valuing one's contribution in a gaming group could involve exchanges related to science, teens seem to also enjoy other aspects of social interactions within their gaming groups that focus less on science learning.

The results of the regression analysis on the nature of science understanding indicate that the six blocks of predictors account for 27% of its variance (R^2 = .27, F (16, 1421) = 33.63, p < .001). However, 19% of the variance is added by the three collective self-esteem subscales indicating their critical relationship with this teen sample's understanding of science.

Identity as a Science Person

The results of the regression on identity as a science person indicate that the ten predictors accounted for about 20% of the variance (R^2 = .20, F (16, 1416) = 22.95, p < .001).

As can be seen in Table 8, the strongest (albeit weak) predictor of identity as a science person was preference for games with science-related features (β= .23, p < .001). Thus, teens who preferred games where they could encounter science-related features were also those for whom science was important to their self. On a related level, problem solving and mastery (β= .14, p < .001) and competence in games with science-related game features also predicted science identity (β= .11, p < .001). Based on the study's conceptualizations of science identity, grounded partly on competence about science knowledge, it is possible to speculate that excelling in problem-solving video game features may encourage science identity growth.

While enjoyment of most science-related game features did not predict identity as a science person, greater enjoyment of problem-solving games was a significant positive, if weak predictor. Similar to the prediction of understanding the nature of science, the importance of enjoying problem-solving games points to possible types of gaming activities that are related to how teens think about science in relation to themselves. Specifically, not only are the teens' science identities related to how much they enjoy the experience of problem-solving, but also to their level of competence level the same.

While these results may be intuitive to a certain extent, this study is one of few to actually document it in a national sample of teens. Essentially, this suggests that factors tied to the world of video games relate to development of identity as a science person. Closer examination of the rest of the regression results further explain how teens' science identities may be developed in games.

Three of the four subscales assessing evaluations of gaming groups were significant predictors, indicating distinct patterns of predictions. Valuing one's membership in gaming groups and identifying strongly with them were related to a stronger science identity. That teens' personal contributions to gaming groups related to identifying more as a science person was reminiscent of the predictor's relationship with understanding of science. In concert, these results allow speculation that the value added by teens in their gaming groups is science-related to some extent at least, with evidence of cognitive clarity on the nature of science as well as personal-level effects on identity as a science person.

Teens' identity as gamers was also aligned with how they felt about themselves in relation to science. Acknowledging that it is not possible to draw causal connections from these data, at the very least they suggest the likelihood of gaming groups providing an arena for science engagement in ways that reflect who they are – not only as members of gaming communities, but also the scientific community. Thus, even if it was not possible to identify the exact ways in which identity develops in a collaborative gaming arena, the results highlight some of the outcomes of teen involvement in this world.

More positive personal evaluation of their gaming groups was related to a weaker science identity, suggesting that evaluations of gaming groups were based on aspects that were less to do with how they

Table 8. Regressions on identity as a science person

	B	SE (B)	β	t	p
Suburb- Dummy Code	1.973	.355	.030	5.56**	.000
Rural- Dummy Code	.054	.050	.026	1.09	.278
Age	.056	.060	-.080	0.93	.352
Gender	.046	.014	-.020	-3.27**	.001
Perceived gaming skill level	.036	.048	-.059	-0.76	.447
Enjoyment of science related game features					
- Problem solving and mastery	.290	.070	.140	4.17**	.000
- Learning from failures	.021	.047	.014	0.46**	.647
- Social aspects (competition or collaboration)	-.009	.041	-.006	-0.22	.827
- Design features	.074	.055	.044	1.35	.177
Application to real life	-.001	.025	-.001	-0.06	.956
Preference for science related game features	.198	.028	.225	7.13**	.000
Competence with science related game features	.079	.022	.111	3.55**	.000
Collective gaming self-esteem					
- Membership	.068	.032	.075	2.10**	.036
- Private	-.070	.036	-.105	-2.89**	.004
- Public	-.010	.038	-.038	-1.17	.244
- Identity	.065	.022	.083	3.25**	.001

Notes. * = p< .05, **= p< .005, R^2 = .197

identified as science persons. Given that these collective self-esteem subscales do not necessarily capture the specific criteria for evaluating gaming groups, it is possible that teens' self-reported personal evaluations had little to do with the science learning potential from these groups. In fact, the data suggest that these evaluations are less about video games' relation to science compared to non-science aspects.

The negative relationship between experience level and science identity indicates that more experienced gamers were identifying more as science people (since the highest skill level [professional] was coded as 1 and the lowest [beginner] level was coded 5). Once again, while the data precluded exploring the specific processes through which this may occur, it highlighted how teens' engagement in video gaming may be related to science identities.

RELATIONSHIPS BETWEEN THE SOCAIL ASPECTS OF GAMING

Rationale for Investigation

The interactive effect of collective self esteem and the types of games played on teenagers' understanding of the nature of science are described in this section. In the first step of this analysis, a regression analysis was conducted to understand how the types of games teenagers played related to their understanding of the nature of science. Predictors in the analysis were demographics (age, gender, area of residence), competence in science-related game features, experience playing video games, followed by the different types of games played in the past week, coded as 1 (Yes) or 0 (No). Game types were included in the regression analysis in the last block, and were those involving a) simulating playing sports, b) making art, c) changing the look of something, like fashion or makeup, d) playing, making music, or dancing, e) simulating cooking, f) racing with obstacles and challenges, g) engaging in battles, that

might include shooting or fighting, h) first person shooter games, i) role playing in fantasy or role playing environments, j) solving word puzzles or challenges, k) learning new facts or information, l) simulating taking care of animals, m) racing with obstacles and challenges, n) solving puzzles or word challenges, o) building cities or environments, p) simulating taking care of animals, and q) conducting scientific investigations, in that order. The regression analysis revealed four game types that significantly predicted understanding the nature of science: engaging in battles ($\beta = .108$, $p < .001$), racing ($\beta = .086$, $p = .001$), building cities and environments ($\beta = .077$, $p = .004$), and solving word puzzles ($\beta = .066$, $p = .014$). Hence subsequent analyses exploring how game types and collective self esteem predicted understanding the nature of science included only these four game types.

Two regression analyses were conducted, exploring the interactive effects of collective self-esteem and game types on understanding the nature of science – one with the game types racing and battle games, and the other with games word puzzles and building cities.

In the last block of each of these moderation analyses, the interactive effect of each collective self-esteem subscale (Member, Private, Public, and Identity) and each of the two games (racing and battle games) were entered, resulting in eight interaction variables. Similarly for the second moderator analysis, the interaction variables were between the collective esteem subscales and build cities and playing word puzzles. For these analyses, the variables measuring the collective self-esteem subscales and game types were standardized, as is the common procedure.

For the first analysis, the interactions between Private subscale and battle games ($\beta = .081$, $p = .019$), and between Identity subscale and race games were significant ($\beta = .046$, $p = .049$), both positively predicting understanding the nature of science.

For the second analysis, the interactions between the Identity subscale and word puzzle games were significant ($\beta = .082$, $p < .001$), positively predicting understanding the nature of science.

To identify the exact nature of the interactive effect, means for median-split groups of those high and low in the collective self-esteem scales were calculated and compared for those who did and did not play each of the games. The figures below depict the specific ways these variables interactively relate to understanding of the nature of science.

As Figure 11 indicates, understanding of the nature of science is high for those who hold a strong positive regard for their gaming group, and especially so for those in this group who also played battle games, compared to those who did not.

Similarly Figure 12 highlights that for the group that identifies strongly with gaming groups it is the subgroup that also plays racing games that understands the nature of science more, compared to the subgroup that does not.

Lastly, Figure 13 points to the fact that the subgroup within the group of self-identified gamers that plays word games, compared to those who do not, also indicate greater understanding of the nature of science.

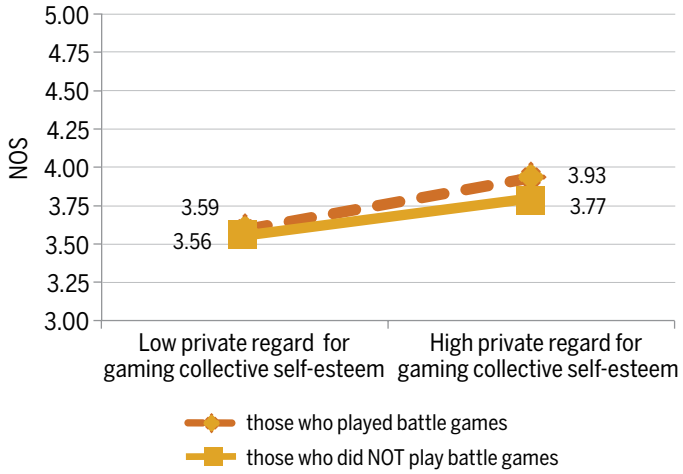

Figure 11: Mean NOS for teens high and low in private self-esteem based on whether or not they played battle games.

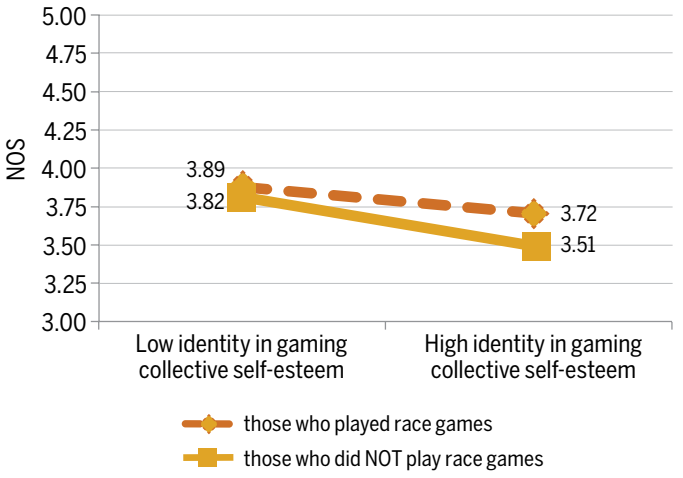

Figure 12: Mean NOS for teens high and low in gaming identity , based on whether or not they played race games.

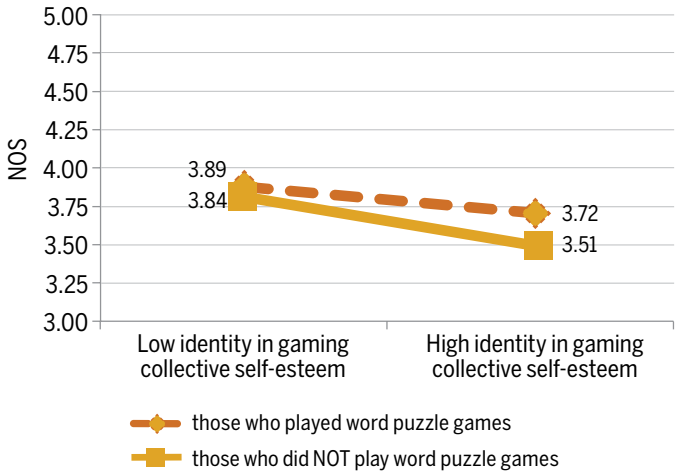

Figure 13: Mean NOS for teens high and low in gaming identity based on whether or not they played puzzle games.

Profile of teens with a limited understanding of the Nature of Science

The research team closely examined the specific characteristics of those who have not developed a strong understanding of the nature of science. Means of those median split groups of those with a high and low understanding of science were compared across the variables assessing frequency of play in various locations such as home, school, etc. The most frequently played game types for the group with low understanding of the nature of science was also examined.

Those teens who have a limited understanding of the nature of science relative to those who understand the nature of science more indicate more frequent game playing at school, during after-school programs or camps, and also through formal programs at the library. These teens' higher frequency of play through existing organized programs (whether in school or libraries) can perhaps be leveraged to transfer science-focused games in these educational contexts. It also appears that gaming in these contexts as they have reported it is less about science learning, and more about personal or social enjoyment. Echoing results that those who strongly identify as gamers understand the nature of science less, these results suggest educational contexts where science learning can be integrated for students to develop a greater understanding of the nature of science.

A closer look at the specific games played and the platforms of choice for the group scoring low on understanding the nature of science further illuminates this group's unique preferences. Figure 14 depicts the most common games played by this group – as can be seen, consoles like Xbox and PSP, computers or laptops, and cell phones are the systems where teens with a low understanding of science typically play video games. As is evident, their platforms of choice are not unlike that of teens with a better understanding of the nature of science.

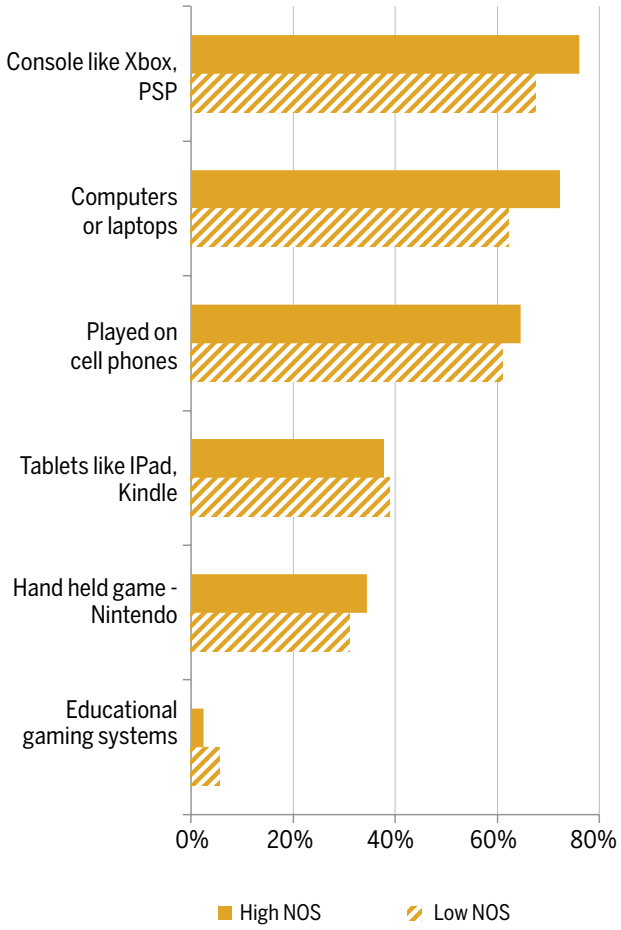

Figure 14: Frequency of gaming platforms for teens, grouped by high and low understanding of the Nature of Science

However, differences were revealed when game preferences were examined further. As Figure 15 indicates, the most frequently played games for the group low in understanding of science were word puzzles and challenges, races with obstacles and challenges, battle games, and first person shooters.

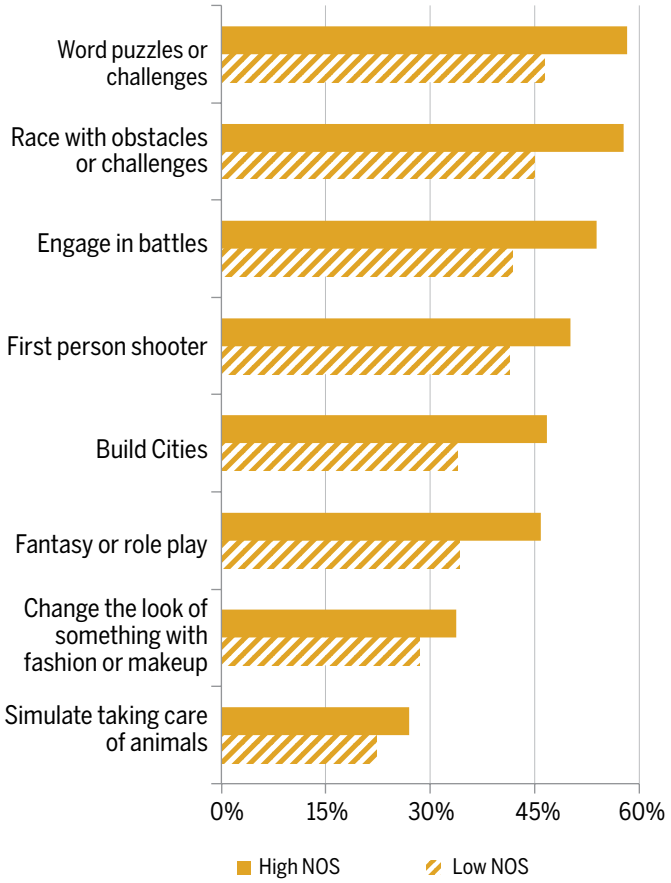

Figure 15: Most frequently played games for teens, grouped by high and low understanding of the Nature of Science.

As the figure also shows, the group scoring high on understanding the nature of science, appears to be playing these games more frequently. In fact, chi square test of independence, examining preferences for each of these three game across the two groups of NOS learners were significant – that is, those high in NOS compared to those low in NOS, played race games more (X^2 (1, N = 1502) = 24.56, p <.001), word puzzles more (X^2 (1, N = 1502) = 21.62, p <.001), battle games (X^2 (1, N = 1502) = 22.09, p <.001), and also first person shooter games more (X^2 (1, N = 1502) = 11.33, p =.001). Even though the low NOS group consistently plays these games less frequently than the high NOS scorers, they do engage in these games more compared to those that involve fantasy and role play, building cities or environments, changing the look of something with fashion or makeup, and simulating taking care of animals. As such, the low NOS group's higher engagement in games involving word puzzles, races, battles, and first-person shooter style, similar to that of the high NOS group suggests that these games could be potentially targeted to include science content that would facilitate the low group's greater understanding of the NOS.

Results of Qualitative Analysis

The Leximancer program provided a helpful visual tool to see how different concepts (i.e., recurring words and similar words) formed larger themes and the ways in which they were connected to one another (Figure 16). Colors signified importance and relevance, where red, orange, and yellow are "hot" topics and green, blue, and purple are themes of less importance.

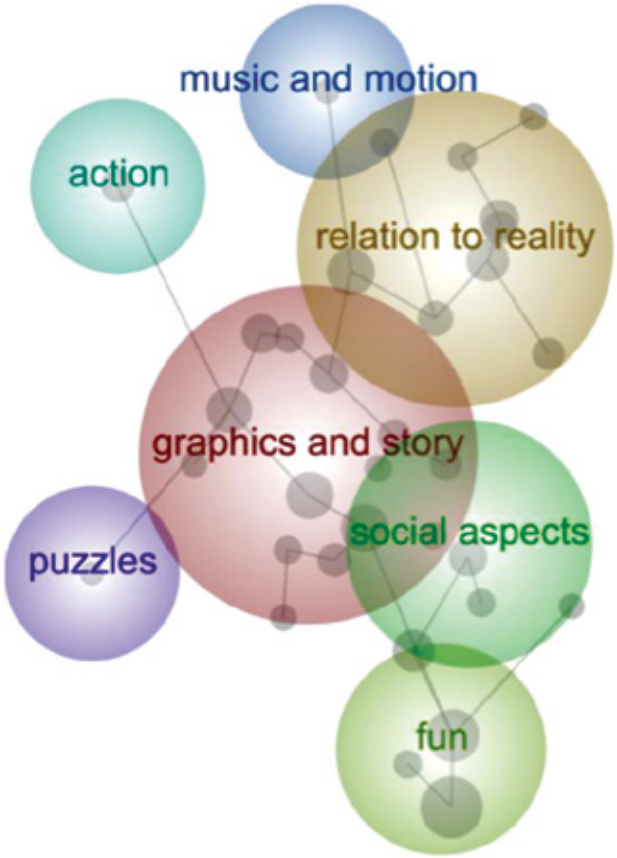

Figure 16: Themes characterizing teen reasoning about game preferences.

The most central theme that emerged from teens' explanations for their favorite games indicated that the games' graphics and storyline were most important. This theme seemed to pull together why a game was a teen favorite. The appreciation for the graphics was often mentioned with other concepts, as the example below indicates:

The graphics, the story, the multiplayer, the characters, EVERYTHING . . .

Looking more closely at the specific concepts associated with this theme (Figure 16), it was evident that the features of these gaming worlds of particular importance to this teen group were the characters and protagonists embedded in the story along with aspects such as the presence of multiple skill levels and interfaces with maps and the potential to explore these worlds for an indefinite period of time. In other words, the visual and imagined worlds created within the games seemed most attractive to teens.

The second most pertinent theme that emerged during the analysis was appreciation for how the game is connected to real life, labeled "Relation to reality." Some teens felt that their favorite game could

teach [them] to solve problems quickly and that these skills can be applied to real life.

Even though they did not specify skills they felt were relevant to real life, there was an acknowledgement of these games' usability beyond the gaming environment. Other teens liked the game because it "simulates real life" or activities in which they engage in real-life, such as football. The simulation to real life also seems to have an element of control for the teens, whereby they could actively learn new information, engage in strategic thinking, as well as create or build.

I like how you can create your character and then make your own experiences in the game with realistic and in some cases costly consequences being the result of many choices found in said experiences.

The third most important theme that emerged was that teens' favorite game was 'fun' to play. Most teens indicated that the reason they liked their favorite game was associated with how much "fun" the games were to play. Others qualified their definition of "fun," equating it with either challenging or easy. In effect, this concept seemed to co-occur with other concepts in ways that explicitly described what made the experience fun for them.

Football, its graphics are totally awesome, it's challenging, fun and makes you think.

The fact that teens' favorite game is deemed "fun" is intuitive to some extent; however, this theme's association with other themes indicated clearer explanations for the fun experienced – immersion in

the fantasy world of the games, their abilities to transcend between fantasy and real life, as well as the social interactions inherent in this world. As such, this finding may be leveraged to design games that could incorporate learning while simultaneously being experienced as fun.

The fourth most important theme revealed was the social aspect of gaming. The social aspects that teens appreciated appeared to be those that enable them to play against (competition) or with (collaboration) other characters or people.

There are different maps, you can play online with people of different skill levels, you can have multiple players.

The social aspect overlapped with other themes, indicating that navigating video gaming worlds with others added to their appeal and made them fun and entertaining.

The three other themes that emerged occurred less frequently and primarily indicated game genres or types that were deemed attractive – those involving action, music, and puzzles.

Teenagers in this study evidently not only appreciated the unique features of a gaming environment, but were also able, to some extent, to recognize this world's connections to the "real" world, external to this medium. In some cases, explicit references were made to activities and strategies used within the gaming world that had applications beyond it. As such, this finding corroborated Egan's (1997) argument for leveraging children and youth's fantasy worlds as arenas to advance learning. Focusing on the cognitive processes employed when navigating these realms, Egan argued that by exploring their limits and extremes, youth construct meaning that builds on their existing ideas and knowledge of the world beyond.

Vygotsky's zone of proximal development (Newman & Holzman, 1995) shed further light on how learning may occur through direct interactions with objects to learn "scientific concepts" that emphasize relationships between objects and ideas. That is video gaming worlds, with their interactive, immersive environment, may provide contexts to explore situated objects, relationships between which can be understood by hypothesizing, experimenting, and inferring.

The key finding that teenagers were able to recognize the utility of gaming activities and concepts in the real world boded well for the concern raised by Biddell and Fischer (1994) about the lack of knowledge transfer between different contexts (primarily formal education and more informal settings). That the interactive influence of the learner and environment has often been overlooked in

Figure 17: Further reasoning on desirable features in games.

education has made it difficult to understand how learning and skill-building occurs. That is, what is learned in one context does not necessarily have a direct application in another. Teenagers' responses in this study indicated that the video gaming environment involves activities and experiences that they felt could be utilized in the real world, a promising find. In fact, there appeared to be a level of ownership and active control of how the lessons from the video game world were used in contexts beyond.

In Biddell and Fischer's words (1994):

From the skill theory perspective, every child is ready to learn, indeed, is learning and developing in daily social interactions in educational contexts. The educator's task is to understand and participate effectively in that process. This perspective removes the

helplessness of the wait-and-leap strategy that stems from the context-neutral approach to cognitive structure and affirms the developmental value of everyday activities of both teachers and learners. The conceptual and methodological tools derived from the context-embedded framework of skill theory can provide educators with options for understanding and intervention in place of the helpless prescriptions of the context-neutral perspectives on developmental education.

In effect, these results pointed to the video gaming worlds as a potential learning context that can be better leveraged to advance learning. Teenagers' recognition of the trans-media potential of skills and learning that occurred in the video game, in effect pointed to the value of this context as a learning environment.

Discussion

This front-end study provided baseline information on a national sample of US teens' gaming preferences and engagement in science through games. Overall, a moderately experienced group of gamers comprised the sample (most indicated their skill level was intermediate), with only a small percentage being highly experienced. The majority of the teens indicated playing games in the few weeks prior to when they answered the online survey. They indicated playing mostly on computers, consoles, and cell phones, and to a lesser extent on hand-held devices and tablets.

Although most teens indicated playing on their own, some were social gamers. Even though most are solo players, it was evident that the teens' knowledge of gaming happened in a social context – they indicated learning about games from friends, family, and gaming websites. A third of the teens in this sample indicated reading online forums and blogs.

Their involvement in a community of gamers was also captured – specifically, their personal evaluations of these groups, the evaluations of others, and their sense of value as a contributor to a gaming group, were moderately positive. Being part of a gaming community didn't have as strong an influence on their personal identity compared to the other subscales, and may be an artifact of their developmental stage, when their personal identity is considered to be in flux. This sample indicates that gaming is not an important aspect of who they are.

The group's understanding of the nature of science was high, especially regarding the tentative nature of science and that scientific knowledge needs to be reviewed and changed. A fairly high awareness of basic scientific principles was indicated. The teens also showed a strong identity as a "science person." This identity seemed to derive from their competence in science, the extent to which engaging in science activities reflected who they are, and others' recognition of themselves as a science-oriented person.

Their reactions to games with science-learning potential also indicated patterns in relation to what they preferred playing, what they were skilled or competent in, and what they enjoyed playing. Albeit related, these different reactions to specific games indicated different relationships with science learning and identity. While their preference for games with science-related features was moderate, their competence in problem-solving games for example, seemed slightly greater. In contrast, their enjoyment of games with science features was indicated to be high. Even though the correlations between preference and enjoyment were generally weak, they do suggest a pattern of teens' gaming preference that is at least tangentially related to science learning.

To investigate how teens' science learning and identity as science people related to their involvement with video game playing, the research team conducted regression analyses. A personal identity derived from one's gaming groups was a critical predictor of both outcomes. Even though it was likely that gaming groups allowed opportunities to exchange science ideas or demonstrate competence in science-related games—relating positively to their science identity for those with a strong gaming identity—this may actually relate to lower levels of science learning. While it was not possible to explore the reasons for this in the current study, it may be conjectured that socially interactive gaming co-occurs with identity-related outcomes that may not relate to science (for example, status and recognition), with negative impacts on science learning. What is suggested is that for understanding the nature of science, especially, their gaming identity mattered less compared to their self-reported competence in problem-solving games.

The other collective self-esteem item that related to the outcomes was valuing one's contribution in the community of gamers. Specifically, this factor was related to greater knowledge about the nature of science as well as their identity as a science person. This made a stronger argument for the speculation that at least part of teens' contribution involved using science concepts in video games in a collaborative space.

In the context of the Leveling Up project that aims to facilitate teenagers' science learning through video games, unique patterns of game play and preferences were evident when the research team looked closely at two groups of teenagers with either a high or low understanding of the nature of science (NOS). Irrespective of their understanding of the NOS, teenagers seemed to play games most frequently on consoles like Xbox and PSP, computers and laptops, and cell phones. Beyond this, both groups' most frequent choices of games were those that involved races, battles, and word puzzles. While the high NOS group appeared to be playing these somewhat more frequently, the overall patterns suggested these games have a broad appeal, with implications for targeting for science learning potential. That is, for the low NOS group, incorporating games that include science learning might be able to facilitate their greater understanding of NOS, similar to how the high NOS group may have developed an understanding of the NOS.

The low NOS group's frequency of play in organized educational contexts such as after-school and library programs highlights yet another arena to engage teenagers in science-based video games. These contexts seem to offer scope for limited science learning relative to those for social interaction. As such, incorporating

science-based games into these contexts can potentially leverage the social aspects of gaming (sense of self-worth through one's personal evaluations of game groups as well as one's own contributions to gaming).

The results also provided evidence for integrating science learning into teens' social gaming world. Specifically for those who identify strongly as gamers, games with word puzzles and races seemed to especially help understand the nature of science. While it was not possible to examine the exact processes in which these games may be related, it may be that word puzzles, often involving rearrangement or searches within grids, may allow scope for developing spatial reasoning that is associated with science learning. Similarly, race games might enable spatial navigation through the courses depicted in the games. Thus, despite the fact that nature of science seemed to be lower for those strongly identified gamers, it was the subgroup of strongly identified gamers who played word puzzles or played race games for whom NOS was high.

For those who held strong positive perceptions of their gaming groups, the subgroup that played battle games were especially likely to understand the NOS, compared to those who had negative views of their gaming groups. It can be speculated that strategies employed in navigating battles and surviving attacks may offer scope for experimenting with a variety of actions may be associated with the higher NOS score. Game play within groups that are considered valuable may offer the scope to try out and learn from strategies in ways that help understand the fundamentals of science learning.

Teenagers' open-ended responses about their favorite games highlighted their phenomenological experiences within the gaming worlds they inhabited. That this immersive context subsumes a universe of its own depicted through characters, stories, graphics, and interactions was greatly appreciated by this group. Moreover, beyond appreciation of features within this world, teenagers were also able to transcend this world to the more real, everyday worlds in which they live, highlighting the potential to learn by transcending media.

Overall the data suggests that learning about science within a video-gaming context occurs in a complex network of preferences, enjoyment, and competence. Skill at playing games in general was similarly associated with a stronger sense of identity as a science person. While it is difficult to draw causal connections from these findings, the results highlight the collaborative, social nature of video game play that has definite implications for science learning and ways in which involvement in science affects perceptions of the self.

A key finding was that between a fifth and a quarter of teens' science understanding and science identity were explained by factors both socially and personally relevant in a video-gaming world. For these cognitive-level outcomes, this level of explanation without a formal science curriculum or instruction embedded in the context presents a powerful argument for investigating science learning in the online, digital gaming world.

Conclusion

This front-end assessment followed up on earlier Pew research to explore teens' gaming habits. Beyond simple patterns of preferences, this study's results suggest that game design does have the potential to support the development of science thinking capacity among youth, transfer of science content to real world settings, and might offer an evenue for supporting increased understanding the nature of science. The evidence of the social nature of video-gaming also suggests that social gamers are likely to derive support from one another in their development of mastery in a game, and this social support may also contribute to increased capacity in science thinking In concert, the instruments and baseline data will serve as a useful measure on which to base future impacts research for the NSF funded Leveling Up research project being pursued by EdGE @ TERC.

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Appendix A: Survey Instrument

Welcome to the survey! We value your input. By clicking "continue" you agree to participate in the following survey on your opinions and experiences using online games. Your responses will contribute to the development of new games. The survey will take approximately 15 minutes. By clicking on "continue" bellow you will be asked a series of questions in this survey. The procedure does not pose any risk and/or discomfort. Your participation is entirely voluntary and you may decline to enter this study or may withdraw from it at any time without jeopardy. The survey will not have a name or any other identifying feature attached to it.

○ Agree and continue ○ I do not wish to continue with this survey

[If I do not wish to continue is Selected, Then Skip To End of Block]

1. We want to know more about how you play digital games. In the past few weeks have you played games on any of the following? Click on all the ones on which you have played.

☐ Cell Phone
☐ Hand held game- like a Nintendo DS or PSVita
☐ Console such as Wi, XBox, Play Station
☐ Tablets like iPad, or Kindle, Nook
☐ Computers or laptops
☐ Leapfrog, or other education game systems
☐ Other _____
☐ None

2. How often do you play digital games at each of these places?

	Daily						Never
At home	○	○	○	○	○	○	○
At school as part of class	○	○	○	○	○	○	○
At an after school program or camp	○	○	○	○	○	○	○
At my friends' homes	○	○	○	○	○	○	○
At the library as part of formal programs	○	○	○	○	○	○	○
At school during free time	○	○	○	○	○	○	○
At the library on my own or with friends	○	○	○	○	○	○	○

3. What types of activities do you like to do in digital games? Select all of the ones that you like to play. I like when I get to:

- ☐ Build cities or environments
- ☐ Simulate playing sports
- ☐ Simulate taking care of animals
- ☐ Make art
- ☐ Change the look of something, like fashion or makeup
- ☐ Race with obstacles and challenges
- ☐ Solve puzzles or word challenges
- ☐ Engage in battles, that might include shooting or fighting
- ☐ Play, make music, or dance
- ☐ Role play in fantasy or role playing environments
- ☐ Simulate cooking
- ☐ Conduct scientific investigations
- ☐ Another activity _____
- ☐ Learn new facts or information
- ☐ Take quizzes to help me with school or entrance exams

4. I like to play games where...

- ☐ I get to play with my friends in the same room
- ☐ I get to play online with people I know
- ☐ I get to play online with people I have never met
- ☐ I like to play my games on my own

5. Tell us about some game features that you enjoy. If you think about the games that you play, how much do you enjoy each of the following? [PS= problem solving and mastery subscale, LF= learning from failure subscale, SC= social subscale, DF= design feature subscale, AP= real life application subscale]

	Not very much	A Little	A Lot	I don't know
Solve problems (PS)	○	○	○	○
Show mastery of the game (PS)	○	○	○	○
Learn from my mistakes (LF)	○	○	○	○
Compete with others (SC)	○	○	○	○
Collaborate with others (SC)	○	○	○	○
Actively shape the game's progress (DF)	○	○	○	○
Choose my skill level (DF)	○	○	○	○
Play roles based on game characters (DF)	○	○	○	○
See the connections between early and later parts of the games (DF)	○	○	○	○
Experience a pleasant level of frustration (PS)	○	○	○	○
Repeat play by practicing (LF)	○	○	○	○
Achieve success (PS)	○	○	○	○
Easily understand the game's goals (PS)	○	○	○	○
Apply game concepts to real life (AP)	○	○	○	○

6. Thinking across the games that you play, how experienced are you at playing digital games?

- ○ Professional
- ○ Expert/Pro
- ○ Intermediate
- ○ Amateur
- ○ Beginner

7. Please list three to four games you have played in the last three weeks...

- ☐ 1: _____
- ☐ 2: _____
- ☐ 3: _____
- ☐ 4: _____

8. How do you find out about the games you play? Click all that apply:

- ☐ Friends
- ☐ Family
- ☐ Teachers
- ☐ TV
- ☐ Game sites
- ☐ iTunes store, or Amazon store
- ☐ Other_____

9. Which game sites do you visit?

10. What is your favorite game of all time?

11. What do you like about *Favorite Game*?

12. For the next few questions, we want to know what you think about science. Remember, there are no "right" or "wrong" answers and you will not be graded on your responses.

	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
*Scientific knowledge does not change with time.	○	○	○	○	○
Scientific knowledge is subject to review and change.	○	○	○	○	○
In developing areas of scientific knowledge, competing theories may be held for a long time.	○	○	○	○	○
Science progresses by refining and replacing old theories with new ones.	○	○	○	○	○
Today's science laws, theories, and concepts may have to be changed in the face of new evidence	○	○	○	○	○
There are still many unresolved issues to be solved in science.	○	○	○	○	○

13. For the next few questions, we want you to continue to think about science. Remember, there are no "right" or "wrong" answers and you will not be graded on your responses.

	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
Scientific truth changes with time.	○	○	○	○	○
Scientists often disagree about scientific knowledge	○	○	○	○	○
*Scientific knowledge is always correct	○	○	○	○	○
*Once a law of science is discovered it should never need to be changed.	○	○	○	○	○
*Scientific knowledge is the same throughout the world.	○	○	○	○	○
Scientific knowledge is verified by experiment..	○	○	○	○	○

14. Again, we want you to continue to think about science. Remember, there are no "right" or "wrong" answers and you will not be graded on your responses.

	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
Science is a search for truth.	○	○	○	○	○
Scientific knowledge gets closer to the truth as time goes by.	○	○	○	○	○
Scientific laws, theories, and concepts are continually being tested.	○	○	○	○	○
Scientific knowledge does not have to be repeatable to be accepted.	○	○	○	○	○
*The evidence to support scientific knowledge need not be communicated to other scientists for their examination.	○	○	○	○	○

15. Please rate to what extent you agree or disagree with the following statements. [Self, Social and Comp are indicators of the three subscales for identity as a science person and were not seen by survey participants]

	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree	N/A
I think of myself as a science person. (Self)	○	○	○	○	○	○
I am comfortable thinking of myself as a science person. (Self)	○	○	○	○	○	○
Things I do (work, study, hobbies) help me think of myself as a science person. (Self)	○	○	○	○	○	○
Teachers/Professors/Instructors see me as a science person. (Social)	○	○	○	○	○	○
My friends see me as a science person. (Social)	○	○	○	○	○	○
My family sees me as a science person. (Social)	○	○	○	○	○	○
It is important to me that others see me as a science person. (Social)	○	○	○	○	○	○

16. Please rate to what extent you agree or disagree with the following statements.

	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree	N/A
I enjoy doing science-related activities (Comp)	○	○	○	○	○	○
I am successful at science-related activities. (Comp)	○	○	○	○	○	○
I understand the basic concepts and principles associated with science inquiry. (Comp)	○	○	○	○	○	○
I can conduct a scientific investigation (Comp)	○	○	○	○	○	○
Doing science-related activities is important to who I am. (Self)	○	○	○	○	○	○
My science knowledge and skills allow me to explain things to other people. (Comp)	○	○	○	○	○	○
My knowledge and skills in science allow me to contribute to issues that are important to me. (Self)	○	○	○	○	○	○

17. Please rate to what extent you agree or disagree with the following statements.

	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
I am a worthy member of the gaming groups I belong to.	○	○	○	○	○
I often regret that I belong to some of my gaming groups.	○	○	○	○	○
Overall, my gaming groups are considered good by my friends.	○	○	○	○	○
Overall, my game memberships have very little to do with how I feel about myself.	○	○	○	○	○
I feel I don't have much to offer to the other gamers for games I play.	○	○	○	○	○
In general, I'm glad to be a member of the gaming groups I belong to.	○	○	○	○	○
Most of my friends, consider my gaming groups, on average, to be more ineffective than IRL (in real life) groups .	○	○	○	○	○
The gaming groups I belong to are an important reflection of who I am.	○	○	○	○	○
I am a cooperative participant in the social games groups I play.	○	○	○	○	○
Overall, I often feel that the gaming groups where I am a member are not worthwhile.	○	○	○	○	○

18. Please rate to what extent you agree or disagree with the following statements.

	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
In general, my friends respect the game groups that I am a member of.	○	○	○	○	○
The game groups I belong to are unimportant to my sense of what kind of person I am.	○	○	○	○	○

19. Please rate to what extent you agree or disagree with the following statements.

	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
I often feel I'm a useless member in social games.	○	○	○	○	○
I feel good about the gaming groups I belong to.	○	○	○	○	○
In general, others think that the gaming groups I am a member of are not worthy.	○	○	○	○	○
In general, belonging to gaming groups is an important part of how I think about myself.	○	○	○	○	○

20. Please rate to what extent you agree or disagree with the following statements.

	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
*I've often frustrated when games don't follow rules of the real world	○	○	○	○	○
What I learn through games helps me at school	○	○	○	○	○
*Games have no connection to the real world	○	○	○	○	○

21. Please rate to what extent you agree or disagree with the following statements.

	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
I'm very good at guessing how to solve a problem in a game	○	○	○	○	○
I like games where I get to try and do something a few times in different ways so I know how it works	○	○	○	○	○
I like the excitement when game rules change	○	○	○	○	○
I like to try and figure out the rules of a game once I'm playing	○	○	○	○	○
I really like to do the demo or tutorial for games before I start to play	○	○	○	○	○

22. Please rate to what extent you agree or disagree with the following statements.

	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
I read gaming information sites, blogs and forum boards	○	○	○	○	○
I contribute to gaming information sites, blogs and forum boards	○	○	○	○	○
I get bored with a game once I can get to the end quickly	○	○	○	○	○
I feel much more relaxed when I play games	○	○	○	○	○
I feel much more relaxed after I play games	○	○	○	○	○

Appendix B: Tables

Table 9. Paired sample T-test with science identity subscales

	M	*SD*	*t*
Importance of science identity to self	3.09	1.00	
- Social validation of science identity			17.71*
- Competence in science activities			28.87*
Social validation of science identity	2.87	1.06	
- Competence in science activities			34.20*
Competence in science activities	3.57	0.87	

Note. * = p< .05, **= p< .005

Table 10. Collective gaming self-esteem

	M	*SD*	*t*
Membership	4.64	1.00	
Membership - Private			-0.53
Membership - Public			7.41**
Membership - Identity			27.10**
Private	4.65	0.92	
Private - Public			8.86**
Private - Identity			29.53**
Public	4.49	0.77	
Public - Identity			24.86**
Identity	3.71	1.02	

Note. * = p< .05, **= p< .005

Table 11. Paired sample T-test with science learning game features

	M	*SD*	*t*
Problem Solving	2.49	0.44	
- Learning from failure			13.81**
- Social Aspects			6.65**
- Design features			6.46**
Learning from failure	2.32	0.58	
- Social Aspects			-3.95**
- Design features			-6.54**
Social Aspects	2.39	0.66	
- Design features			-1.84
Design features	2.42	0.54	

Note. * = p< .05, **= p< .005

Appendix C: Item Response Data

1. In the past few weeks have you played games on any of the following? Click on all the ones on which you have played.

	Cell Phone	Hand held game	Console	Tablets	Computers	Educational game system	Other	None
Selected	942 (62.7%)	492 (32.8%)	1077 (71.7%)	576 (38.3%)	1009 (67.2%)	62 (4.1%)	48 (3.2%)	92 (6.1%)
Total	1502	1502	1502	1502	1502	1502	1502	1502

2. How often do you play digital games at each of these places?

	Daily (1)	(2)	(3)	(4)	(5)	(6)	Never (7)
At home	861	317	88	66	32	54	84
	57.3%	21.1%	5.9%	4.4%	2.1%	3.6%	5.6%
At school as part of class	95	88	89	80	69	146	935
	6.3%	5.9%	5.9%	5.3%	4.6%	9.7%	62.3%
At an after school program or camp	90	97	70	62	37	88	1058
	6.0%	6.5%	4.7%	4.1%	2.5%	5.9%	70.4%
At my friends' home	147	296	215	208	129	194	313
	9.8%	19.7%	14.3%	13.8%	8.6%	12.9%	20.8%
At school during free time	270	248	139	85	47	104	09
	18.0%	16.5%	9.3%	5.7%	3.1%	6.9%	40.5%
At the library on my own or with friends	98	119	90	100	55	107	933
	6.5%	7.9%	6.0%	6.7%	3.7%	7.1%	62.1%

	M	Median	Mode	SD	N
At home	2.06	1	1	1.72	1502
At school as part of class	5.74	7	7	1.97	1502
At an after school program or camp	5.90	7	7	1.96	1502
At my friends' homes	4.14	4	7	2.07	1502
At the library as part of formal programs	6.20	7	7	1.67	1502
At school during free time	4.42	5	7	2.48	1502
At the library on my own or with friends	5.63	7	7	2.06	1502

3. What types of activities do you like to do in digital games? Select all of the ones that you like to play. I like when I get to:

	Selected	% Selected		Selected	% Selected
Another activity	52	3.5%	Play, make music, or dance	727	48.4%
Build cities or environments	605	40.3%	Race with obstacles and challenges	772	51.4%
Change the look of something, like fashion or makeup	467	31.1%	Role play in fantasy or role playing environments	602	40.1%
Conduct scientific investigations	216	14.4%	Simulate cooking	362	24.1%
Engage in battles that might include shooting or fighting	719	47.9%	Simulate playing sports	502	33.4%
First person shooter games (FPS)	687	45.7%	Simulate taking care of animals	370	24.6%
Learn new facts or information	402	26.8%	Solve puzzles or word challenges	786	52.3%
Make art	426	28.4%			

4. I like to play games where...

	I get to play with my friends in the same room	I get to play online with people I know	I get to play online with people I have never met	I like to play my games on my own
Selected	876 (58%)	829 (55%)	640 (43%)	1186 (79%)
Not Selected	626 (42%)	673 (45%)	862 (57%)	316 (21%)
Total	1502	1502	1502	1502

5. Tell us about some game features that you enjoy. If you think about the games that you play, how much do you enjoy each of the following? [PS= problem solving and mastery subscale, LF= learning from failure subscale, SC= social subscale, DF= design feature subscale, AP= real life application subscale]

	Not very much	A Little	A Lot	Total
Solve problems (PS)	193 (13%)	552 (37%)	706 (47%)	1451
Show mastery of the game (PS)	144 (10%)	406 (27%)	866 (58%)	1416
Learn from my mistakes (LF)	143 (10%)	614 (41%)	677 (45%)	1434
Compete with others (SC)	188 (13%)	397 (26%)	844 (56%)	1429
Collaborate with others (SC)	251 (17%)	480 (32%)	685 (46%)	1416
Actively shape the game's progress (DF)	183 (12%)	477 (32%)	714 (48%)	1374
Choose my skill level (DF)	111 (7%)	393 (26%)	905 (60%)	1409
Play roles based on game characters (DF)	235 (16%)	434 (29%)	740 (49%)	1409
See the connections between early and later parts of the games (DF)	198 (13%)	492 (33%)	673 (45%)	1363
Experience a pleasant level of frustration (PS)	271 (18%)	604 (40%)	553 (37%)	1428
Repeat play by practicing (LF)	235 (16%)	572 (38%)	611 (41%)	1418
Achieve success (PS)	73 (5%)	190 (13%)	1122 (75%)	1385
Easily understand the game's goals (PS)	84 (6%)	300 (20%)	1022 (68%)	1406
Apply game concepts to real life (AP)	296 (20%)	540 (36%)	535 (36%)	1371

6. Thinking across the games that you play, how experienced are you at playing digital games?

	Professional	Expert/ Pro	Intermediate	Amateur	Beginner
Selected	85	401	727	177	112
Percent	6%	27%	48%	12%	8%
Total	1502				

7. Please list three to four games you have played in the last three weeks... (Most frequently recorded games)

	Game	Frequency		Game	Frequency
1.	Call of Duty (Black Ops & Modern Warfare)	515	6.	Minecraft	99
2.	Halo	200	7.	Angry Birds	91
3.	Mario	131	8.	Temple Run	82
4.	The Sims	124	9.	Grand Theft Auto	79
5.	Madden (includes NFL)	123	10.	Assasin's Creed	77

8. How do you find out about the games you play? Click all that apply:

	Friends	Family	Teachers	TV	Game sites	iTunes store or Amazon store	Other
Selected	1175	636	69	634	729	439	143
Percent	78%	42%	5%	42%	49%	29%	10%
Total	1942						

9. Which game sites do you visit?

	Game Site	Frequency
1.	Game Stop	131
2.	IGN	62
3.	Gamefly	37
4.	Game Spot	26
5.	Xbox/ addicting games	20

10. What is your favorite game of all time? (77 responded with "none", or they "didn't have one")

	Game	Frequency		Game	Frequency
1.	Call of Duty (includes Black Ops and Modern Warfare)	181	6.	Minecraft/ Grand Theft Auto	39
2.	The Sims	81	7.	Just Dance	29
3.	Halo	75	8.	Skyrim	28
4.	Mario	59	9.	Temple Run	27
5.	Madden (includes NFL)	41	10.	Mario Kart/ Angry Birds	21

11. What do you like about *Favorite Game*?

(See chapter Results of the Qualitative Analysis)

12, 13, 14. For the next few questions, we want to know what you think about science. Remember, there are no "right" or "wrong" answers and you will not be graded on your responses. (Asterisk reflects statements that were reverse coded for analysis, presented here as original data to reflect frequencies, but descriptive statistics reflect reverse coded values).

	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
*Scientific knowledge does not change with time.	496 (33%)	473 (32%)	311 (21%)	148 (10%)	74 (5%)
Scientific knowledge is subject to review and change.	30 (2%)	56 (4%)	281 (19%)	730 (49%)	405 (27%)
In developing areas of scientific knowledge, competing theories may be held for a long time.	28 (2%)	43 (3%)	481 (32%)	702 (47%)	248 (17%)
Science progresses by refining and replacing old theories with new ones.	39 (3%)	57 (4%)	381 (25%)	697 (46%)	328 (22%)
Today's science laws, theories, and concepts may have to be changed in the face of new evidence.	30 (2%)	43 (3%)	387 (26%)	670 (45%)	372 (25%)
There are still many unresolved issues to be solved in science.	27 (2%)	27 (2%)	240 (16%)	597 (40%)	611 (41%)
Scientific truth changes with time.	46 (3%)	82 (6%)	383 (25%)	721 (48%)	270 (18%)
Scientists often disagree about scientific knowledge.	38 (3%)	74 (5%)	380 (25%)	693 (46%)	317 (21%)
*Scientific knowledge is always correct.	287 (19%)	565 (38%)	434 (29%)	156 (10%)	60 (4%)
*Once a law of science is discovered it should never need to be changed.	333 (22%)	561 (37%)	388 (26%)	159 (11%)	61 (4%)
*Scientific knowledge is the same throughout the world.	224 (15%)	508 (34%)	461 (31%)	229 (15%)	80 (5%)
Scientific knowledge is verified by experiment.	26 (2%)	48 (3%)	353 (23%)	754 (50%)	321 (21%)
Science is a search for truth.	34 (2%)	55 (4%)	346 (23%)	692 (46%)	375 (25%)
Scientific knowledge gets closer to the truth as time goes by.	36 (2%)	94 (6%)	556 (37%)	604 (40%)	212 (14%)
Scientific laws, theories, and concepts are continually being tested.	23 (2%)	22 (1%)	260 (17%)	741 (49%)	456 (30%)
Scientific knowledge does not have to be repeatable to be accepted.	231 (15%)	393 (26%)	511 (34%)	299 (20%)	68 (5%)
*The evidence to support scientific knowledge need not be communicated to other scientists for their examination.	319 (21%)	367 (24%)	411 (27%)	297 (20%)	108 (7%)

12, 13, 14. continued

Descriptive Statistics	M	Median	Mode	SD	N
*Scientific knowledge does not change with time.	3.78	4	5	1.15	1502
Scientific knowledge is subject to review and change.	3.95	4	4	.88	1502
In developing areas of scientific knowledge, competing theories may be held for a long time.	3.73	4	4	.83	1502
Science progresses by refining and replacing old theories with new ones.	3.81	4	4	.91	1502
Today's science laws, theories, and concepts may have to be changed in the face of new evidence.	3.87	4	4	.89	1502
There are still many unresolved issues to be solved in science.	4.16	4	5	.88	1502
Scientific truth changes with time.	3.72	4	4	.92	1502
Scientists often disagree about scientific knowledge.	3.78	4	4	.92	1502
*Scientific knowledge is always correct.	3.57	4	4	1.04	1502
*Once a law of science is discovered it should never need to be changed.	3.62	4	4	1.06	1502
*Scientific knowledge is the same throughout the world.	3.38	3	4	1.08	1502
Scientific knowledge is verified by experiment.	3.86	4	4	.85	1502
Science is a search for truth.	3.88	4	4	.90	1502
Scientific knowledge gets closer to the truth as time goes by.	3.57	4	4	.89	1502
Scientific laws, theories, and concepts are continually being tested.	4.06	4	4	.82	1502
Scientific knowledge does not have to be repeatable to be accepted.	2.72	3	3	1.09	1502
*The evidence to support scientific knowledge need not be communicated to other scientists for their examination.	3.32	3	3	1.21	1502

15, 16. Please rate to what extent you agree or disagree with the following statements. [Self, Social and Comp are indicators of the three subscales for identity as a science person and were not seen by survey participants]

Frequencies	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree	N/A
I think of myself as a science person. (Self)	210 (14%)	335 (22%)	368 (25%)	405 (27%)	154 (10%)	30
I am comfortable thinking of myself as a science person. (Self)	153 (10%)	266 (17%)	425 (28%)	439 (29%)	186 (12%)	33
Things I do (work, study, hobbies) help me think of myself as a science person. (Self)	176 (11%)	342 (23%)	422 (28%)	380 (25%)	156 (10%)	26
Teachers/Professors/Instructors see me as a science person. (Social)	174 (11%)	335 (22%)	421 (28%)	395 (26%)	138 (9%)	39
My friends see me as a science person. (Social)	213 (14%)	385 (26%)	393 (26%)	331 (22%)	141 (9%)	39
My family sees me as a science person. (Social)	193 (13%)	355 (24%)	368 (25%)	395 (26%)	161 (11%)	30
It is important to me that others see me as a science person. (Social)	264 (18%)	449 (30%)	440 (29%)	197 (13%)	112 (8%)	40
I enjoy doing science-related activities (Comp)	95 (6%)	147 (10%)	380 (25%)	594 (40%)	256 (17%)	30
I am successful at science-related activities. (Comp)	77 (5%)	131 (9%)	374 (25%)	657 (44%)	229 (15%)	34
I understand the basic concepts and principles associated with science inquiry. (Comp)	62 (4%)	92 (6%)	327 (22%)	700 (47%)	290 (19%)	31
I can conduct a scientific investigation (Comp)	100 (7%)	123 (8%)	377 (25%)	642 (43%)	219 (15%)	41
Doing science-related activities is important to who I am. (Self)	172 (12%)	320 (21%)	488 (33%)	327 (22%)	160 (11%)	35
My science knowledge and skills allow me to explain things to other people. (Comp)	89 (6%)	143 (10%)	393 (26%)	601 (40%)	247 (16%)	29
My knowledge and skills in science allow me to contribute to issues that are important to me. (Self)	102 (7%)	2157 (11%)	475 (32%)	531 (35%)	187 (13%)	50

15, 16. (continued)

Descriptive Statistics	M	Median	Mode	SD	N
I think of myself as a science person. (Self)	2.91	3	4	1.28	1502
I am comfortable thinking of myself as a science person. (Self)	3.09	3	4	1.25	1502
Things I do (work, study, hobbies) help me think of myself as a science person. (Self)	2.95	3	3	1.23	1502
Teachers/Professors/Instructors see me as a science person. (Social)	2.91	3	3	1.24	1502
My friends see me as a science person. (Social)	2.79	3	3	1.27	1502
My family sees me as a science person. (Social)	2.92	3	4	1.27	1502
It is important to me that others see me as a science person. (Social)	2.55	2	2	1.21	1502
I enjoy doing science-related activities (Comp)	3.45	4	4	1.19	1502
I am successful at science-related activities. (Comp)	3.48	4	4	1.14	1502
I understand the basic concepts and principles associated with science inquiry. (Comp)	3.65	4	4	1.11	1502
I can conduct a scientific investigation (Comp)	3.42	4	4	1.20	1502
Doing science-related activities is important to who I am. (Self)	2.92	3	3	1.23	1502
My science knowledge and skills allow me to explain things to other people. (Comp)	3.46	4	4	1.16	1502
My knowledge and skills in science allow me to contribute to issues that are important to me. (Self)	3.26	3	4	1.21	1502

17, 18, 19. Please rate to what extent you agree or disagree with the following statements. (Asterik reflects statements that were reverse coded for analysis, presented in the frequency table and the descriptive statistics table as reverse coded data (items in parentheses are references only)) (Strongly Disagree=1, Neither=4, Strongly Agree= 7).

	1	2	3	4	5	6	7
I am a worthy member of the gaming groups I belong to. (Q14_1)	69 (5%)	59 (4%)	86 (6%)	515 (34%)	336 (22%)	313 (21%)	124 (8%)
*I often regret that I belong to some of my gaming groups. (Q14_2)	46 (3%)	86 (6%)	148 (10%)	483 (32%)	224 (15%)	290 (19%)	225 (15%)
Overall, my gaming groups are considered good by my friends. (Q14_3)	57 (4%)	58 (4%)	74 (5%)	555 (37%)	386 (26%)	271 (18%)	101 (7%)
*Overall, my game memberships have very little to do with how I feel about myself. (Q14_4)	155 (10%)	281 (19%)	309 (21%)	511 (34%)	112 (8%)	66 (4%)	68 (5%)
*I feel I don't have much to offer to the other gamers for games I play. (Q14_5)	54 (4%)	115 (8%)	187 (13%)	471 (31%)	253 (17%)	255 (17%)	167 (11%)
In general, I'm glad to be a member of the gaming groups I belong to. (Q14_6)	56 (4%)	46 (3%)	58 (4%)	502 (33%)	391 (26%)	312 (21%)	137 (9%)
*Most of my friends, consider my gaming groups, on average, to be more ineffective than IRL (in real life) groups. (Q14_7)	52 (4%)	126 (8%)	230 (15%)	702 (47%)	134 (9%)	141 (9%)	117 (8%)
The gaming groups I belong to are an important reflection of who I am. (Q14_8)	140 (9%)	155 (10%)	156 (10%)	542 (36%)	273 (18%)	161 (11%)	75 (5%)
I am a cooperative participant in the social games groups I play. (Q14_9)	59 (4%)	65 (4%)	67 (5%)	438 (29%)	402 (27%)	332 (22%)	139 (9%)
*Overall, I often feel that the gaming groups where I am a member are not worthwhile. (Q14_10)	54 (4%)	89 (6%)	192 (13%)	576 (38%)	217 (14%)	231 (15%)	143 (10%)
In general, my friends respect the game groups that I am a member of. (Q14_1)	48 (3%)	36 (2%)	46 (3%)	568 (38%)	339 (23%)	348 (23%)	117 (8%)
*The game groups I belong to are unimportant to my sense of what kind of person I am. (Q14_2)	149 (10%)	216 (14%)	248 (17%)	542 (36%)	121 (8%)	120 (8%)	106 (7%)
*I often feel I'm a useless member in social games. (Q15_1)	44 (3%)	90 (6%)	159 (11%)	454 (30%)	178 (12%)	311 (21%)	266 (18%)
I feel good about the gaming groups I belong to. (Q15_2)	50 (3%)	21 (1%)	52 (4%)	547 (36%)	341 (23%)	368 (25%)	123 (8%)
*In general, others think that the gaming groups I am a member of are not worthy. (Q15_3)	39 (3%)	89 (6%)	142 (10%)	621 (41%)	171 (11%)	258 (17%)	182 (12%)
In general, belonging to gaming groups is an important part of how I think about myself. (Q15_4)	197 (13%)	170 (11%)	144 (10%)	556 (37%)	219 (15%)	160 (11%)	56 (4%)

17, 18, 19. continued

Descriptive Statistics	M	Median	Mode	SD	N
I am a worthy member of the gaming groups I belong to. (Q14_1)	4.61	5	4	1.43	1502
*I often regret that I belong to some of my gaming groups. (Q14_2)	4.68	4	4	1.56	1502
Overall, my gaming groups are considered good by my friends. (Q14_3)	4.58	5	4	1.34	1502
*Overall, my game memberships have very little to do with how I feel about myself. (Q14_4)	3.41	4	4	1.48	1502
*I feel I don't have much to offer to the other gamers for games I play. (Q14_5)	4.46	4	4	1.56	1502
In general, I'm glad to be a member of the gaming groups I belong to. (Q14_6)	4.74	5	4	1.37	1502
*Most of my friends, consider my gaming groups, on average, to be more ineffective than IRL (in real life) groups. (Q14_7)	4.09	4	4	1.40	1502
The gaming groups I belong to are an important reflection of who I am. (Q14_8)	3.96	4	4	1.55	1502
I am a cooperative participant in the social games groups I play. (Q14_9)	4.74	5	4	1.42	1502
*Overall, I often feel that the gaming groups where I am a member are not worthwhile. (Q14_10)	4.38	4	4	1.47	1502
In general, my friends respect the game groups that I am a member of. (Q14_1)	4.75	5	4	1.31	1502
*The game groups I belong to are unimportant to my sense of what kind of person I am. (Q14_2)	3.70	4	4	1.61	1502
*I often feel I'm a useless member in social games. (Q15_1)	4.75	5	4	1.61	1502
I feel good about the gaming groups I belong to. (Q15_2)	4.80	5	4	1.30	1502
*In general, others think that the gaming groups I am a member of are not worthy. (Q15_3)	4.53	4	4	1.48	1502
In general, belonging to gaming groups is an important part of how I think about myself. (Q15_4)	3.75	4	4	1.61	1502

20. Please rate to what extent you agree or disagree with the following statements (Asterik reflects statements that were reverse coded for analysis, presented here as reverse coded results) (Strongly Disagree=1, Neither=4, Strongly Agree= 7)

Frequencies	1	2	3	4	5	6	7
*I'm often frustrated when games don't follow rules of the real world	38 (3%)	129 (9%)	217 (14%)	420 (28%)	242 (16%)	254 (17%)	202 (13%)
What I learn through games helps me at school	120 (8%)	157 (11%)	150 (10%)	477 (32%)	381 (25%)	162 (11%)	55 (4%)
*Games have no connection to the real world	93 (6%)	173 (12%)	236 (16%)	377 (25%)	316 (21%)	183 (12%)	124 (8%)

Descriptive Statistics	M	Median	Mode	SD	N
*I'm often frustrated when games don't follow rules of the real world	4.51	4	4	1.58	1502
What I learn through games helps me at school	4.03	4	4	1.50	1502
*Games have no connection to the real world	4.13	4	4	1.61	1502

21. Please rate to what extent you agree or disagree with the following statements. (Strongly Disagree=1, Neither=4, Strongly Agree= 7)

	1	2	3	4	5	6	7
I'm very good at guessing how to solve a problem in a game	28 (2%)	39 (3%)	59 (4%)	283 (19%)	478 (32%)	430 (27%)	185 (12%)
I like games where I get to try and do something a few times in different ways so I know how it works	31 (2%)	29 (2%)	61 (4%)	335 (22%)	490 (33%)	379 (25%)	177 (12%)
I like the excitement when game rules change	47 (3%)	80 (5%)	185 (12%)	477 (32%)	366 (24%)	233 (16%)	114 (8%)
I like to try and figure out the rules of a game once I'm playing	41 (3%)	42 (3%)	75 (5%)	317 (21%)	474 (32%)	370 (25%)	183 (12%)
I really like to do the demo or tutorial for games before I start to play	98 (7%)	121 (8%)	168 (11%)	372 (25%)	362 (24%)	245 (16%)	136 (9%)

Descriptive Statistics	M	Median	Mode	SD	N
I'm very good at guessing how to solve a problem in a game	5.11	5	5	1.28	1502
I like games where I get to try and do something a few times in different ways so I know how it works	5.04	5	5	1.27	1502
I like the excitement when game rules change	4.46	4	4	1.40	1502
I like to try and figure out the rules of a game once I'm playing	4.99	5	5	1.35	1502
I really like to do the demo or tutorial for games before I start to play	4.37	4	4	1.61	1502

22. Please rate to what extent you agree or disagree with the following statements. (Strongly Disagree=1, Neither=4, Strongly Agree= 7)

	1	2	3	4	5	6	7
I read gaming information sites, blogs and forum boards	247 (16%)	182 (12%)	133 (9%)	312 (21%)	329 (22%)	209 (14%)	90 (6%)
I contribute to gaming information sites, blogs and forum boards	347 (23%)	255 (17%)	150 (10%)	345 (23%)	195 (13%)	144 (10%)	66 (4%)
I get bored with a game once I can get to the end quickly	78 (5%)	112 (8%)	134 (9%)	319 (21%)	381 (25%)	305 (20%)	173 (12%)
I feel much more relaxed when I play games	56 (4%)	58 (4%)	89 (6%)	379 (25%)	438 (29%)	321 (21%)	161 (11%)
I feel much more relaxed after I play games	63 (4%)	57 (4%)	90 (6%)	449 (30%)	403 (27%)	294 (20%)	146 (10%)

Descriptive Statistics	M	Median	Mode	SD	N
I read gaming information sites, blogs and forum boards	3.85	4	5	1.83	1502
I contribute to gaming information sites, blogs and forum boards	3.32	3	1	1.82	1502
I get bored with a game once I can get to the end quickly	4.61	5	5	1.61	1502
I feel much more relaxed when I play games	4.79	5	5	1.43	1502
I feel much more relaxed after I play games	4.69	5	4	1.43	1502

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tel: (347) 766-3399
349 Fifth Ave., Suite 405
New York NY 10016

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