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Youth science identity, science learning, and gaming experiences

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ABSTRACT

This study explored the relationships between identity, science learning, and gaming. A survey of 1502 teenagers assessed gaming preferences, habits, science learning, science and gamer identities. Hierarchical regression analyses revealed that enjoyment of problem-solving games and identifying as a gamer were the strongest predictors for teens' science understanding. Teen preferences for games with science-related features, and competence in problem-solving games were significant predictors of teens' understanding of science. Teens who preferred collaborative social games over science-oriented games were less likely to understand the nature of science. Teens with a stronger science identity were more likely to negatively evaluate their gaming groups, preferred problem-solving games, and claimed greater competence in games with science-related features when compared to those who do not self-identify as science thinkers. Results suggest that games that seek to support those who do not feel successful in science learning should focus on social interaction and involve activities and experiences that could be utilized in the real world rather than problem solving games. Results suggest that science-focused games may reinforce perceived self-efficacy and sense of competence in real world scientific reasoning situations for those already predisposed to feel confident as science thinkers.

1. Introduction

The Pew Internet and American Life Project reported that over 92% of youth play video games teens report playing for at least an hour during each gaming session, and most American teens play five or more genres of games (Lenhart et al., 2008). Gaming genres played by teens vary widely and include rhythm-based games, puzzle/card games, sports games, and first-person shooter games, with teens reporting that they play these games more frequently each year (Lenhart, Purcell, Smith, & Zickuhr, 2010; Lenhart et al., 2008). Recent research has begun to explore both the positive and negative consequences of game play. Consequently, there is mounting evidence of science reasoning in gaming environment such as *Quest Atlantis*, *River City*, *Wolf Quest*, *Environmental Detectives*, and *Martian Boneyards* (Asbell-Clarke et al., 2012; Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005; Dede, Clarke, Ketelhut, Nelson, & Bowman, 2005; Klopfer & Squire, 2008). Furthermore, recent research has suggested that youth game-play has the potential to contribute to their science learning (i.e. Clark, Nelson, Sengupta & D'Angelo, 2009; Gee, 2007). However, research is still needed to explore whether/how teens construct their science identity through these gaming environments to determine how teen identity development might be enhanced and/or hindered through immersion in video game worlds.

1.1. Science identity and gaming

Acknowledging that identity is socially constructed, Carlone and Johnson (2007) theorize that identity development occurs through interpersonal experiences, has impacts on learning, predicts behaviors, and relates to one's understanding of the self. Science identity contains three dimensions: (1) competence and mastery with science-related content and activities, (2) social performance with science-related content when interacting with others, and (3) recognition or validation from oneself and others as a science person (Carlone & Johnson, 2007). The gaming environment provides an immersive space for science-learning that has the potential to develop, modify, and/or limit one's notion of their science identity (Shaffer, Squire, Halverson, & Gee, 2005). Furthermore, an individual's differentiation and integration within a group structure shape the individual's identity development as it relates to and influences their group identity (Adams & Marshall, 1996). Through formal education, teens are given increasing opportunities to modify and expand their identities to incorporate

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conceptualizations of themselves as *science people* (Beier, Miller, & Wang, 2012). However, Carlone and Johnson's identity model has not yet been used applied to gamers' perceptions of themselves as science people, specifically in relation to their game-play experiences and their interactions with their peer gaming groups.

Gaming may represent one area of exploration in which youth compartmentalize other parts of their sense of self (Fraser, Gupta, & Rank, 2013; Sylvan, Asbell-Clarke, Fraser, Gupta, & Rowe, 2013). Video games provide a context by which youth engage in new forms of identity that may differ from their offline expressions of themselves (Przybylski, Weinstein, Murayama, Lynch, & Ryan, 2012). Current research is beginning to suggest that youth experiences on digital environments greatly influence their identity development (Dodge et al., 2008). However, research is needed to identify how teens are experimenting with their science identity to determine how their identity is modified, maintained, and/or determined by their video game engagement and their engagement with peers through video game platforms.

1.2. Science learning and gaming

Egan (1997) argues that by pushing their limits, youth construct meaning based on their pre-existing knowledge. When immersed within specific gaming worlds, youth may receive opportunities to incorporate this previous knowledge into the game, while expanding on this knowledge by creating meaning from the gaming experience. The nature of science (NOS) field of knowledge, as defined by previous researchers (Lederman, 1992), represents one potential area of pre-existing knowledge in which youth can build upon through video games. NOS has been described as the understanding of science as a way of knowing, or the values and assumptions that are inherent in the development of scientific knowledge (Lederman, 1992). Expanding upon Lederman's definition, Schwartz and Crawford (2004) identified three essential factors for NOS learning – reflection, context, and perspective, all of which align to how gaming might encourage synthesis of content knowledge to hypothetical conditions.

The gaming world could provide youth learners with opportunities to use each of these skills, in addition to affording youth with opportunities to critically examine and apply science topics in an effort to solve problems embedded in video games (Squire, Barnett, Grant, & Higginbotham, 2004). Previous studies have found that video games can facilitate scientific inquiry, data analysis, and theory-building skills (Asbell-Clarke et al., 2012). There is a growing body of research suggesting that gaming environments can enhance youths' learning (Barab et al., 2005; DeFreitas, Rebolledo-Mendez, Liarokapis, Magoulas, & Poulovassilis, 2010; Gee, 2007; Ketelhut, 2007; Lenhart et al., 2008; Steinkuehler & Duncan, 2008), and video games can be leveraged as environments that promote learning processes (Harpstead, Myers, & Aleven, 2013). However, research is needed to determine the processes by which video games can be used to enhance learning experiences for youth (McClarty et al., 2012).

Video games can provide youth with opportunities to develop situated understandings, effective social strategies, personal and varied identities, share values with peers, and engage in communities of practice (Shaffer et al., 2005). Gaming worlds provide contexts in which learners can explore situated concepts (Gee, 2007), where object-relationships can be understood by hypothesizing, experimenting, and inferring from the manipulation of such objects. Gee (2007) originally identified four specific aspects of games that are relevant to positive learning outcomes: (1) display of problem-solving or mastery; (2) learning from failure to eventually win; (3) competition as a social event; (4) 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 (5) role-playing potential. While all of these attributes likely contribute to learning outcomes, the theoretical focus in the science-learning game research has tended to treat gamers as an undifferentiated mass, occasionally considering gender as a discriminatory tool. The research has neglected to explore potential psychographic variations that may influence learner genre preference. The authors hypothesize that a game's genre may pre-determine who will prefer and play the game, and then what learning might be achieved given the gamer's specific preferences.

Not surprisingly, students prefer learning science through the use of video games (Marino, Israel, Beecher, & Basham, 2013). The consistent, non-social rewards (e.g. level changes, accumulated coins) available in video games serve to motivate youth, enhance youth interests, and increase their overall engagement in the game (Garris, Ahlers, & Driskell, 2002). Once youth are engaged in science-based games, studies have found numerous benefits for the player such as enhanced understanding of complex science phenomena (Kafai, Quintero, & Feldon, 2010; Klopfer, 2008; Plass et al., 2013; Squire et al., 2004; Steinkuehler & Duncan, 2008), and improved spatial reasoning skills (Greenfield, Brannon, & Lohr, 1994).

Similarly, strategic video game play has been directly linked with teen's increased problem-solving abilities and overall academic performance (Adachi & Willoughby, 2013). Video games are vivid, interactive environments in which gamers can engage in learning environments that bring to life abstract concepts and ideas embedded in more traditional curriculum (Evans, Anderson, Chang, Deater-Deckard, & Balci, 2013). The active involvement elicited by video games, the goals presented, and the visual representations of complex science concepts may be related to science learning, however, many of these items have not been empirically tested. Despite the growing recognition of video games as effective instructional tools, the exact mechanisms by which they impart science learning has yet to be determined (Evans et al., 2013). Furthermore, there is limited research on how teens' preconceptions of themselves as science thinkers might influence the degree to which science-learning games or genres are useful for teens' science learning.

1.3. Social self

Situated within a scaffolding approach to learning (Vygotsky, 1987), Salomon and Perkins (1998) suggest that learning is not an individualized process nor is it a completely social process, but learning is instead a combination of individual and social processes. In a review of the learning literature, Salomon and Perkins identify how individual learning can be socially mediated. Individual learners may participate in a collective group where learning is distributed in the group more than in the individual, and the individual and social dimensions of learning interact in a "reciprocal spiral relationship." Consequently, teens' learning processes should be considered as embedded within social constructions.

In the context of the gaming world, it is likely that the group dynamics of the gaming experience may serve as an influential factor, contributing to students' understanding of science (Squire et al., 2004). Indeed, previous research has suggested that the social aspects of video games are attractive for youth players (Frostling-Henningsson, 2009; Jansz & Martens, 2005; Trepte, Reinecke, & Juechems, 2012). These video games represent a modern tool that can be used to inculcate new cultural norms and practices through shared environments, shared learning, and practice within a group setting (Shaffer et al., 2005). Research has indicated that the virtual, social component of video games can significantly improve learners' engagement and motivation with learning material (Plass et al., 2013). Video game worlds may satisfy socialization