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What do children and adolescents say they do during video game play?☆

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ABSTRACT

We examined the problem-solving behaviors that 5th, 6th, and 7th graders used to negotiate a novel recreational video game. Students were characterized as frequent or infrequent players and instructed to think aloud during game play for 20 consecutive minutes. Comments were used to make inferences about the students' problem-solving behaviors while playing. These comments were then linked to game performance. Among all students, the greatest number of comments concerned their actions and game events at a given point in game play. Females made greater reference to strategies for game play and process goals whereas males made greater reference to their evaluations of the game and when they reached an impasse. Among 5th graders, reference to impasse and rules for game play was linked to better game performance; among 7th graders, reference to insight about how to enact a specific move or circumvent an impasse was related to better performance.

The prominence of video game play as a leisure activity is unequivocal: 72% of US households play video or computer games (Entertainment Software Association, 2011) and 11 to 14-year-olds play them nearly 90 min a day (Rideout, Foehr, & Roberts, 2010). In fact, children ostensibly begin their involvement with video games as early as age two (see Neilsen Company's report, *The State of the Console*, 2007). These findings attest to the appeal and prevalence of video game play in the lives of children and adolescents. Much of this appeal is attributable to the challenges inherent in video games (see Boyan & Sherry, 2011; Sherry, Lucasm, Greenberg, & Lachlan, 2006). For example, popular video games typically require the mastery of a complex multi-cued environment, simultaneous monitoring of multiple game features and events, and negotiation of frequent failures and impasses. Accordingly, recreational video game play is often seen as providing a motivating and engaging context in which to engage in scientific reasoning and more generally, problem-solving (see Fisch, Lesh, Motoki, Crespo, & Melfi, 2011; Steinkuhler & Duncan, 2008). Further, findings demonstrate that video game play is linked to the enhancement of cognitive skills that support problem-solving (Green, Li, & Bavelier, 2009; Karle, Watter, & Shedden, 2010; Sims & Mayer, 2002; Spence & Feng, 2010) such as metacognition (VanDeventer & White, 2002), inductive reasoning (Greenfield, Camaioni, Ercolani, Weiss, et al., 1994; Pillay, 2002), perspective taking (DiPietro, Ferdig, Boyer, & Black, 2007; Kafai, 1995), selective attention (Blumberg, 1998; 2000; Green & Bavelier, 2006a,b), and visual attention and memory (Boot, Kramer, Simons, Fabiani, & Gratton, 2008; Green & Bavelier, 2003).

Despite strong interest in the potential academic value of recreational video game play for the enhancement of problem-solving (see Gee, 2003; Satwicz & Stevens, 2008; Squire, 2006) and heavily funded efforts to incorporate video game play into elementary and secondary-level curriculum (see MacArthur Foundation Digital Media Digital Learning Initiative), few investigators have subjected this interest to scientific scrutiny among populations other than young adults (see De Lisi & Wolford, 2002; Papastergiou, 2009). Thus, little is known about children and adolescents' problem-solving behavior or their approaches to learning in the context of recreational video game play. A prerequisite to bridging this gap entails identifying what it is that children and adolescents do during video game play. Consistent with a problem-solving framework, in which an individual engages in behaviors and actions to advance toward a desired outcome (see Anderson, 1993), players' problem-solving skills are expected to include identification of goals that may be directed to an overarching outcome such as beating a level or a more intermediary outcome such as breaking through a wall to gain extra lives. Players also would be expected to show evidence of strategies designed to reach these goals, monitoring of their progress en route to those goals, and insight about what actions or modifications in strategies might be needed at a given point in game play. Further, players would be expected to recognize having reached an impasse, which might in turn, prompt reassessment of goals for game play (see Pirolli & Recker, 1995; VanLehn & Jones, 1994; VanLehn, Siler, & Murray, 2003).

Interest in the nexus of video game play and children's learning has not been a prominent thrust in current developmental journals.

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However, this relationship was the focus of a special volume (15) of *Journal of Applied Developmental Psychology* in 1994. One study within the volume by Subrahmanyam and Greenfield (1994), for example, examined the extent to which the playing of a game, *Marble Madness*, which highlighted dynamic spatial skills, enhanced fifth graders' (between 10 ½ and 11 ½ years of age) spatial skills. Findings showed improved spatial skill performance among those children who played the game relative to their counterparts who played a game, *Conjecture*, that emphasized word skills. Further, the greatest improvement in spatial skills for those children who played *Marble Madness* was found among those children who showed relatively weak spatial skills before playing.

Also featured within the volume was a study by Okagaki and Frensch (1994) which showed that experience playing the video game *Tetris*, which highlights mental rotation and spatial visualization, resulted in improved performance on tasks assessing these skills among late adolescents and young adults (*M*age = 19.93). Other skills that were found to be enhanced as a result of video game play were inductive reasoning (Greenfield, Camaioni, Ercolani, Weiss, et al., 1994), and divided attention (Greenfield, DeWinstanley, Kilpatrick, & Kaye, 1994). Overall, the developmental period featured in the majority of the special issue's articles was that of traditional college-age students.

This emphasis on young adulthood continues to be maintained, as undergraduate participants comprise most of the samples used in studies examining the ramifications of video game play for cognitive skill enhancement. Studies by Green and Bavelier (2003, 2006a, 2007) and by Boot et al. (2008) have demonstrated that frequent playing of first-person shooter or action video games enhances aspects of visual attention including visual acuity, spatial distribution of attention, and the ability to monitor several simultaneously moving objects. The possibility of replicating these findings among child and adolescent populations, however, remains unlikely given the prevailing view within the psychological community (and more generally) that violent video game play facilitates aggressive and undesirable social behavior (see Anderson et al., 2003; Gentile, Lynch, Linder, & Walsh, 2004).

However, independent of whether the game played is violent or more innocuous in nature, frequency of play has emerged as a contributing factor to the cognitive skills enhanced via video game play. In one of the few studies to examine this factor among child players, VanDeventer and White (2002) found that 10- and 11-year-old children who were frequent video game players made greater reference to cognitively sophisticated behaviors such as planning and anticipating moves in a video game than infrequent players when instructing adults how to play. Similarly, Blumberg and Sokol (2004) found that 8- and 10-year-old frequent video game players were more likely to cite "trial and error" as their strategy of choice for learning to play a game than infrequent game players, who were more inclined to cite asking for help from others. In fact, willingness to experiment or risk failure during a game has been cited as characteristic of sophisticated video game play (see VanDeventer & White, 2002).

The present study was designed to examine the type of problem-solving approaches to playing that might be shown over the course of a novel recreational video game among fifth- through seventh graders who were frequent or infrequent players. We selected fifth graders as our youngest age group given the presumed cognitive sophistication of children by about age 10 in their ability to selectively attend (see Miller & Seier, 1994) and use of efficient memory strategies (see Lehmann & Hasselhorn, 2010). Notably, our age range (ages 10–14) coincides with that which was recently cited as showing high levels of video game use (see Rideout et al., 2010).

Our goal was to illustrate children and adolescents' approaches to game play by asking participants to think aloud while playing over a sustained period of time. The "think aloud" procedure is a long-standing methodological technique for making overt thoughts and strategies during the performance of a task (see Ericsson & Simon, 1993) that has been found to be nonreactive with that performance (Fox, Ericsson, & Best, 2011). This procedure has been used in diverse contexts such as the analysis of historical documents (Wineburg, 1991, 1998); solving of mathematics problems (Rosenzweig, Krawec, & Montague, 2011); and mastery of digital games (Hong & Liu, 2003). Boot, Blakely, and Simons (2011) also have cited that the use of a think aloud procedure is a potent vehicle for elucidating strategies and shifts in strategies used by frequent and infrequent players during the course of a video game. In fact, this approach was recently used by Blumberg, Rosenthal, and Randall (2008) among adult players.

In their study, frequent and infrequent adult players also were asked to play a novel video game for 20 min while thinking aloud. The goal was to elucidate how adults circumvented game impasses encountered during game play. The authors found that participants, regardless of frequency of play, seldom mentioned impasses encountered. Participants did, however, make reference to sudden insight about how to enact a particular move or how to avoid game obstacles, strategies for navigating a particular level or aspect of the game, process goals for enacting a specific move or learning, and making plans to enact a given move, and more long-range or outcome goals for beating a level or winning the game. Frequent players, in particular, made greater references to insight and strategies for playing the game than infrequent players. Particularly surprising was that all players made recurrent references to their specific actions during the game (e.g., dodging an enemy) which may be seen as evidence of players' focused efforts to monitor their game play.

Among the child and adolescent participants in the present study, we expected that frequent players would show greater reference to problem-solving skills as reflected in comments about game goals, strategies, insight, and impasse given their presumed greater understanding of how to negotiate game play. Similarly, we expected greater references to these behaviors with increases in grade and frequency of play whereby the greatest references would be found among the seventh graders who were frequent players.

Method

Participants

The participants included 60 fifth graders (36 male, 24 female; *M*age = 9.91, *SD* = 4.16), 37 sixth graders (15 male, 22 female; *M*age = 11.46, *SD* = 2.01), and 39 seventh graders (18 male, 21 female; *M*age = 12.49, *SD* = 1.77) drawn from ethnically diverse private and public middle schools within New York City.

We relied on parental and child self-report to classify participants as either frequent (played 3 or more times a week) or infrequent (played 2 or fewer times per week) players. There was a significant correlation between the parent's and the child's report of game playing frequency, $r = .462$, $p < .001$, $N = 136$. Table 1 shows the distribution of frequent and infrequent players by sex and grade. A chi-square analysis yielded no significant differences between the distributions of frequent and infrequent players by grade. However, a chi-square analysis for the distributions of frequent and infrequent players by sex yielded a significant difference, $\chi^2\,(1) = 8.74$, $N = 136$, $p = .003$.

Procedure

During the first phase of the study, participants were trained to "think aloud" while solving two mathematical word problems; one

Table 1
Distribution of frequent and infrequent video game players ($N = 136$).

Grade	Frequent ($n = 60$)		Infrequent ($n = 76$)	
	Male	Female	Male	Female
Grade 5 ($n = 60$)	22	7	14	17
Grade 6 ($n = 37$)	8	10	7	12
Grade 7 (n = 39)	9	4	9	17

that the experimenter solved (requiring the operations of multiplication and addition) and one that the participant solved (requiring the operation of division). Both problems were selected for their appropriateness for fifth graders according to New York State curriculum guidelines. The same problems were utilized for all participants in the same order. The experimenter first modeled the think-aloud process with problem one and the participant was asked to then use the process to solve problem two. When participants demonstrated difficulty solving the problem on their own, assistance was provided, with added prompting that they think aloud as they followed the experimenter's reasoning.

During the 5- to 8-min training, participants were actively encouraged to continually vocalize their thoughts about how to solve the problem through a series of prompts of the form, "What are you doing now?" provided by the experimenter after 8 s of non-vocalization. This technique was maintained throughout the playing of the subsequent video game.

During the experimental phase of the study, each participant individually played a non-violent adventure game developed by Sega, *Sonic the Hedgehog 2 for Game Gear*, for 20 min. This game was selected for its potential novelty among participants given its initial introduction into the video game market in the early 1990s, for its presumed appeal among females and males of the targeted age range, and for its use in prior investigations of video game play (see Blumberg, 1998, 2000; Blumberg et al., 2008). The Entertainment Software Rating Board (nd) rating for the game was "E" for everyone. The game contains eight different zones, which are comprised of three acts per zone. On the third act of each zone is a "boss" or difficult obstacle that must be overcome to continue to the next zone. At the onset of the game, a player is given three "Sonics," or lives, that allows for three rounds of play. Lives are lost through contact with dynamic hazards (e.g., spikes that fall from the ceiling) or static hazards (e.g., lava). When a player loses a Sonic on a given act, the game reverts to the beginning of that act. The game is designed to allow the level of difficulty and presentation of hazards to increase as the player's knowledge and skills in the game increase. This common structure of video games, in general, ensures ample opportunity for players to learn about the game, the characteristics of various obstacles, and the techniques for overcoming them.

Game play comments were audiotaped for later transcription and coding. Consistent with prior research that used this game (Blumberg, 1998, 2000), the following dependent variables were used to characterize actual game performance: 1) number of levels completed; 2) highest level attained; 3) number of "Sonics" lost; and 4) number of games started. These variables were recorded by the experimenter for each participant during game play.

Immediately following game play, participants were asked to assess how much they liked the game on a five point scale (1 = *disliked very much*; 5 = *liked very much*). Responses to this question were also audiotaped.

Coding of comments

Transcripts were made of all participants' comments during video game play and were verified by an independent reader using the original audiotapes. Comments were labeled by act and round of play. In accordance with Chi's (1997) method for quantifying verbal protocols, each transcript was segmented into meaningful units or grains for coding. A grain was designated as the smallest possible grouping of words that conveyed meaning in the game context, such as the phrase "running fast." All transcripts were parsed by two independent readers. Interrater reliability, as assessed by percentage agreement, for what constituted a grain averaged 92% across the entire sample of transcripts.

Each transcript was then "sanitized" such that certain words and short phrases that were deemed "silence filler" comments such as "oh," "huh," and "ah," were removed. These sanitized transcripts were used for all analyses reported below. A coding scheme, as adapted from prior research (Blumberg, 1998, 2000; Blumberg et al., 2008), was used to describe grains within these transcripts. In total, five major coding themes were used to characterize grains in the transcripts: 1) cognitive processes, 2) goal-oriented, 3) affective, 4) game-oriented, and 5) context-oriented. Each theme then comprised two or more categories. All grains, across all transcripts, were coded once only for membership within a specific category within a given theme. All transcripts were read by 2 independent readers. Interrater reliability, as assessed by percentage agreement, averaged 86% across all transcripts.

The themes and their categories are described below and accompanied by illustrative participant comments.

Cognitive process comments

This theme included reference to cognitive processes that occurred during game play. These comments were subcategorized into *impasse recognition*, which included acknowledgement that further actions would be unsuccessful or that progress is halted (e.g., "Now I can't go back up so I'm sticking on the ground."), and *insight*, which reflected the sudden recognition of a new strategy or how to negotiate an impasse (e.g., "I need to get coins or I'll die automatically.").

Goal comments

This theme included references to specific goals for game play. These comments were subcategorized as *process goals*, or goals pertaining to completion of a specific sub-goal such as avoiding an obstacle or determining how to use a feature integral to the game console, such as a control button (e.g., "Trying to get to a trolley thing so I can get to the other side."), or *outcome goals*, which included comments pertaining to completing or reaching certain levels of the game (e.g., "I'm trying to win the game.").

Game-oriented comments

This theme included comments that referenced specific game aspects, techniques, and prior experience with digital games. These comments were further classified as one of 5 categories. *Game progress* referred to specific moves or events at a particular point in time (e.g., "I got picked up by that helicopter again."). *Game strategies* pertained to specific moves utilized within game play with reference to the consequences of an action or inaction (e.g., "I jumped off a tube to move me diagonal."). *Game mechanics* made reference to how to use game functions integral to the game console to enact a move, change parameters of the game presented, to pause, or turn the game console on and off, and *game rules* referred to how many rings were needed to obtain a free life (e.g., "I'm starting over so I pressed start."). *Game cues* referenced specific game features, such as the landscape, or game characters (e.g., "a crab."). Finally, *background knowledge* reflected prior experience with comparable games played in the past (e.g., "This is like a Gameboy.").

Affective comments

This theme included comments referencing *game evaluations* that referred to how much the player enjoyed the game (e.g., "It's interesting this game you rented.") and *performance evaluations*, which were personal appraisals of game performance (e.g., "When you lose you actually get the feeling that you're learning something about it.").

Context-oriented comments

This theme included comments that referenced the experimental context, which were further delineated into *experimental context* comments that concerned participation in the study and had limited to no relationship to actual game play (e.g., "Am I almost done with this?"), and *off-task* comments (e.g., "Do you know when we have to go to lunch?").

Results

The findings below concern participants' game performance, the comments they made while playing, and the relationship between those comments and their game performance. Although the variable of sex was not included as part of the original design, preliminary analysis indicated that it impacted game performance and game comments. Accordingly, it is included in most of the analyses reported below.

Game performance

Participants' performance while playing was characterized by four indicators used in prior research (Blumberg et al., 2008): highest level reached, number of levels completed, number of Sonics lost, and number of games initiated. The first two variables are best characterized as indicators of "good" performance whereas the latter two are indicators of "poor" performance. A principal components analysis yielded a component with eigenvalue 1.89 that accounted for 47.3% of the variance. The factor loadings for each of the four variables are shown in Table 2 and indicate that the factor is positively correlated with good performance indicators, and negatively correlated with poor performance indicators. This new variable, referred to as "game performance," was normalized to have mean 0 and standard deviation 1, and was used in subsequent analyses of performance. A 3 (grade) × 2 (sex) × 2 (frequency of play) ANOVA on the game performance score yielded no main effects or interactions.

Game performance and game evaluation

Participants evaluated the game on a 5-point scale. Overall, the game was rated fairly highly ($M = 3.62$, $SD = 1.14$). A 2 (frequency of play) × 2 (sex) × 3 (grade) ANOVA of game evaluation ratings yielded a main effect of sex, $F(1, 124) = 7.97$, $p = .006$, $n^2p = .060$, as boys ($M = 3.96$; $SD = 0.96$) evaluated the game more highly than girls ($M = 3.28$; $SD = 1.21$). Game evaluations were significantly correlated with game performance, $r = .199$, $p = .020$, $N = 136$, such that greater liking of the game was related to better performance.

Game comments

The 5 major coding themes discussed above (cognitive, goal, game, affective, and context) yielded 15 categories of comment. Five categories (i.e., outcome goals, background knowledge, performance evaluation, experimental context, and off-task) were excluded from analyses reported below because they each accounted for less than 0.5% of the comments. Although non-codeable responses accounted for 1% of the responses, this category also was dropped from further analyses given its lack of informative value. The means and standard deviations of the number of comments made during game play for the remaining 9 categories are shown in Table 3.

In total, 20,737 comments were made across categories included in the analyses. Game progress comments were the most common, with process goal, and game strategy comments a distant second and third, respectively. A 3 (grade) × 2 (frequency of play) × 2 (sex) MANOVA of the number of comments in each of the 9 categories yielded a significant grade by sex interaction, Wilks' $\Lambda = .753$, $F(18, 232) = 1.96$, $p = .013$, $n^2p = .13$, which was significant for impasse comments $F(2, 124) = 4.45$, $p = .014$; $n^2p = .067$, and for game evaluation $F(2, 124) = 5.72$, $p = .004$; $n^2p = .085$. The results of a Tukey's post-hoc test showed that fifth-grade males made significantly more impasse comments ($p = .002$) and game evaluation comments ($p = .037$) than fifth-grade females. See Tables 4a and 4b for means and standard deviations by grade and sex for impasse and game evaluation comments, respectively.

A chi-square analysis of the distributions of comments for each of the categories by frequency of play, grade, and sex showed them to be significantly different as indicated: frequency of play, χ^2 (8) = 87.00, $N = 20737$, $p < .001$; grade, χ^2 (16) = 216.26, $N = 20737$, $p < .001$); and sex, χ^2 (16) = 117.27, $N = 20737$, $p < .001$. Because the total number of comments made by participants differed widely (minimum number of comments = 47; maximum number of comments = 440; $M = 152.48$, $SD = 67.14$), subsequent analyses of comments were conducted using the proportion of comments made in each category per participant to give equal weight to all participants.

Game comments across the game play session

To examine changes in participants' comments over the course of game play, two approaches were taken. First, comments in the first and last games started were compared. Second, the comments were ordered by time and split into 10 blocks to give a finer description of the patterns of comments over time.

Some participants played as few as two games and some as many as seven, $M = 4.96$, $SD = 1.04$. For the proportion of comments made in each category, a 3 (grade) × 2 (first or last game) × 2 (frequency of play) × 2 (sex) MANOVA was performed yielding a grade by sex interaction, $F(18, 480) = 1.77$, $p = .026$; $\text{n}^2p = .062$, which was significant for strategy comments, $F(2, 248) = 5.71$, $p = .004$; $n^2p = .044$.

To continue to investigate participants' problem-solving over the course of 20 min of game play, the comments were ordered by time and divided into 10 roughly equal blocks. The block number ranges from 1 to 10, where 1 is the first block and 10 is the last, and is referred to below as time. The proportion of comments in each block was used as the dependent variable for a linear regression for grade × frequency × sex × time. This analysis yielded a significant effect of grade, Wilks' $\Lambda = .978$, $F(8, 1348) = 3.75$, $p = .000$, $n^2p = .022$, which was significantly related to process goals, $F(1, 1355) = 19.70$, $p = .000$, $n^2p = .014$, $\beta = -.014$, and game progress comments, $F(1, 1355) = 7.71$, $p = .006$, $n^2p = .006$, $\beta = .016$. Specifically, reference to process goals decreased as grade level increased; reference to game progress increased as grade level increased.

A significant effect of sex also was found, Wilks' $\Lambda = .971$, $F(8, 1348) = 5.02$, $p = .000$, $n^2p = .029$, which was significantly related to impasse, $F(1, 1355) = 8.58$, $p = .003$, $n^2p = .006$, $\beta = -.008$, and process goals, $F(1, 1355) = 23.66$, $p = .000$, $n^2p = .017$, $\beta = .027$. Specifically, females made fewer references to impasse and made greater reference to process goals.

Game comments at the point of impasse

To further understand the particular problem-solving approaches participants may have used to negotiate their game play, we examined their comments at the point of an impasse. This investigation entailed calculating the proportion of comments in each category following a given category. Table 5 shows the proportions rounded to an integral percentage. Thus, the table shows that following an impasse comment, 66% of the next immediate comments were game progress comments, 10% were impasse comments, 8% were strategy comments, and 7% were process goal comments. This distribution differs from the corresponding percentages for all comments; 83% for game progress, 6% for process goals, and 5% for game strategies. A chi-square analysis of the distribution of comments across categories for all comments and for those following an impasse indicated that the distributions were significantly different, $\chi^2(8) = 218.45$, $N = 206010$, $p = .000$.

Table 2
Factor loadings for the game performance variables.

Variable	Factor loading
Highest level reached	.706
Total levels completed	.664
Sonics lost	−.752
Games started	−.765

Table 3
Means and standard deviations for number of comments made by category during game play across grades[a].

Category	Grade 5		Grade 6		Grade 7		Total	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Cognitive processes								
Impasse	3.28	4.52	2.14	2.87	2.77	3.01	2.82	3.73
Insight	1.48	2.81	0.68	1.45	1.31	2.04	1.21	2.30
Goal-oriented								
Process goals	9.97	10.84	9.22	8.47	6.70	7.33	8.82	9.36
Affective								
Game evaluation	1.40	2.89	0.27	0.65	1.21	2.89	1.04	2.52
Game-oriented								
Game strategies	6.57	7.86	8.43	10.59	7.64	7.13	7.38	8.47
Game mechanics	0.98	2.71	0.84	2.50	1.59	4.90	1.12	3.43
Game cues	2.97	5.88	1.73	3.52	3.51	5.52	2.79	5.24
Game rules	2.03	14.06	0.14	0.42	1.10	5.43	1.25	9.76
Game progress	120.22	62.22	119.76	55.23	140.97	68.30	126.04	62.52

[a] Exclusive of categories accounting for less than 0.5% of the comments and the non-codeable responses.

Game comments stratified by grade

For each grade, the proportion of comments in each category across the 10 blocks was analyzed by time. The results of a multivariate regression for each of fifth and sixth grades failed to show significant findings. However, for seventh graders, a significant effect of time was found, Wilks' $\Lambda = .939$, $F(8, 381) = 3.11$, $p = .002$, $n^2p = .061$, which was significantly related to game cues, $F(1, 388) = 7.64$, $p = .006$, $n^2p = .016$, $\beta = -.002$, game progress, $F(1, 388) = 6.20$, $p = .013$, $n^2p = .016$, $\beta = .007$, and game rules, $F(1, 388) = 6.07$, $p = .014$, $n^2p = .015$, $\beta = -.003$. Specifically, reference to game cues and game rules decreased over time; reference to game progress, however, increased over time.

Comments were also analyzed for each grade separately using a multivariate regression by frequency of play. No significant findings were obtained.

Comments were further analyzed for each grade separately using a multivariate regression by sex, yielding significant findings for 5th graders only, Wilks' $\Lambda = .646$, $F(8, 51) = 3.50$, $p = .003$, $n^2p = .354$, that were significantly related to impasse, $F(1, 58) = 10.96$, $p = .002$, $n^2p = .159$, $\beta = -.022$; strategies, $F(1, 58) = 5.17$, $p = .027$, $n^2p = .082$, $\beta = .029$; process goals, $F(1, 58) = 5.71$, $p = .020$, $n^2p = .090$, $\beta = .044$; and game evaluation, $F(1, 58) = 8.27$, $p = .006$, $n^2p = .125$, $\beta = -.011$. Thus, males made greater references to impasse and game evaluation comments; females made greater reference to game strategies and process goals.

Relationship between game comments and game performance

A 3 (grade) × 2 (frequency of play) × 2 (sex) ANOVA of the number of words uttered in comments yielded a main effect of sex, $F(1, 134) = 5.88$, $p = .017$, $n^2p = .042$, whereby males were more verbose ($M = 894.70$, $SD = 375.51$) than females ($M = 736.82$, $SD = 383.53$). Verbosity was correlated with game performance among sixth graders ($r = .342$, $p = .038$, $N = 37$), and among females ($r = .340$, $p = .005$, $N = 67$).

Spearman's Rho non-parametric correlations were also calculated to determine whether the number of specific comments made during game play was related to actual game performance. For all participants, impasse comments ($r = .301$, $p < .001$, $N = 136$), reference to game cues ($r = .189$, $p = .027$, $N = 136$), and rules comments ($r = .380$, $p < .001$, $N = 136$) were all associated with better game performance. Among the fifth graders, reference to impasse ($r = .356$, $p = .005$, $N = 60$) and game rules ($r = .565$, $p < .001$, $N = 60$) was associated with better game performance. For the seventh graders reference to insight ($r = .394$, $p = .013$, $N = 39$) was associated with better game performance.

Among frequent players, reference to impasse ($r = .369$, $p = .004$, $N = 60$), insight ($r = .273$, $p = .035$, $N = 60$), and game rules ($r = .615$, $p < .001$, $N = 60$) were correlated with better game performance. Among males, reference to impasse ($r = .316$, $p = .008$, $N = 69$) and game rules ($r = .574$, $p < .001$, $N = 69$) was associated with better game performance but reference to game progress ($r = -.247$, $p = .040$, $N = 69$) was associated with worse game performance. For females, reference to game cues ($r = .255$, $p = .037$, $N = 67$) was associated with better game performance.

Discussion

Our goal for examining problem-solving behavior in the context of video game play was based in findings that children and adolescents typically avail themselves of this context for recreational purposes. Further, findings among largely adult populations indicate that the playing of recreational video games may have ramifications for cognitive skill use and problem-solving ability. Thus, our study was designed to investigate the skills and problem-solving approaches that both frequent and infrequent child and adolescent video game players used to negotiate a novel video game. These skills and approaches were inferred from the type of comments made in the think-aloud protocols that were gathered during 20 min of game play. We expected that these comments would highlight participants' identification of goals for game play, strategies for managing that play, insight about the efficacy of actions initiated during play, and acknowledgement of when an impasse had been reached. Participants made greatest note of their game progress while playing regardless of grade or frequency of play, albeit less so after having noted reaching an impasse. Overall, this finding is consistent with

Table 4a
Number of impasse comments by grade and sex.

	Male		Female		Total	
	M	*SD*	*M*	*SD*	*M*	*SD*
Grade 5	4.78	5.11	1.04	1.97	3.28	4.52
Grade 6	2.00	2.10	2.23	3.34	2.13	2.87
Grade 7	3.00	3.36	2.57	2.74	2.77	3.01
Total	3.71	4.31	1.91	2.76	2.82	3.73

Table 4b
Number of game evaluation comments by grade and sex.

	Male		Female		Total	
	M	*SD*	*M*	*SD*	*M*	*SD*
Grade 5	2.17	3.52	0.25	0.53	1.40	2.89
Grade 6	0.13	0.35	0.36	0.79	0.27	0.65
Grade 7	0.72	1.45	1.62	3.71	1.21	2.89
Total	1.35	2.78	0.72	2.20	1.04	2.52

Table 5
Proportion of comments by category following each category of comments.

	Category	1	2	3	4	5	6	7	8	9
1.	Impasse	10	2	8	7	0	1	66	4	2
2.	Insight	4	9	8	10	0	2	64	1	2
3.	Strategies	4	2	15	9	1	3	67	0	0
4.	Process goals	3	1	8	16	0	2	68	0	1
5.	Game mechanics	1	1	1	3	25	1	67	0	1
6.	Game cues	1	1	3	5	1	15	72	1	0
7.	Progress	1	1	4	5	1	1	86	0	1
8.	Rules	8	2	2	2	0	1	14	70	1
9.	Game evaluation	4	2	6	4	1	1	65	1	16

that found among adult participants (Blumberg et al., 2008) and may reflect participants' monitoring of their actions and consequences of actions during game play. This assiduous monitoring may not be surprising given that participants needed to learn a novel game during a relatively brief play session.

The question arises, however, as to what game comments indicate about participants' problem-solving during the game as opposed to other more obvious references to such problem-solving such as goals, game strategies, and insight, which were mentioned far less frequently. This issue clearly warrants greater consideration and potentially supplemental methods for assessing participants' problem-solving during game play. Two techniques that have been used to supplement the concurrent think-aloud approach, as used in the present study, are those of retrospective and cued retrospective think-alouds (see Van den Haak, De Jong, & Schellens, 2003). These techniques have been used to examine participants' problem-solving skills and entail having participants review and report on their actions as prompted via, for example, a screen-shot or video-tape of their behavior during a given task (van Gog, Paas, van Merriënboer, & Witte, 2005). The use of these types of think-alouds could highlight the problem-solving approaches participants consider at the time in which their comments refer to game progress only and also may further elucidate participants' adjustments or modifications to problem-solving at the point of impasse, which is often seen as the impetus for learning (Roberts & Erdos, 1993). In fact, our findings show that participants' patterns of comment at the point of impasse looked different from their patterns across the game at large. This difference is partially reflected in the decreased proportion of game progress comments that followed mention of an impasse.

Contrary to our expectations, frequent players were no more likely to make reference to game strategies, insight, process goals, outcome goals, or impasse comments than infrequent players. Similarly, our expectation that seventh-grade frequent players would show the greatest reference to these comments was not supported. We did, however, find developmental differences in emphases for game play whereby reference to process goals decreased by grade and reference to game progress comments increased by grade. Thus, the younger students showed greater reference to goals for their game play over the 20 min whereas the older students showed greater vigilance to their contemporaneous actions and those of the game during play. In fact, examination of the seventh graders' comments over the course of game play showed further evidence of a decreasing reference to game cues and rules in conjunction with their increasing reference to game progress. One might surmise that among the seventh graders, a focus on the specifics of game play, as reflected in the game progress comments, may have appeared sufficient to master the game. However, with regard to their actual performance, reference to insight only was related to better game. Another reason why seventh graders in the present study may have failed to show greater reference to problem-solving behaviors over the course of game play may be attributed to the type of game used in the present study. For example, the game used here was originally marketed during the early 1990s and although all participants generally liked it, it may have presented as less challenging than the more contemporary digital games that seventh graders in our study may play.

Our findings did provide evidence of sex differences, some of which were surprising. For example, males were more verbose than females in the number of words uttered in their comments. However, these differences were not necessarily reflected in better game performance as verbosity was positively associated with game performance only among sixth graders and among females. Sex differences also were evident in the types of comments made. For example, among fifth graders, males made greater reference to impasse and evaluation of the game than females. Among all fifth graders, reference to impasse and rules of the game were linked to better performance. Further sex differences were found among frequent players whereby references to impasse and game rules was linked to greater performance among males and reference to game cues among females was related to greater performance. These findings attest to differential emphases for game play between the males and females in the study whereby the former seem more attendant to points of failure (i.e., impasse) in their game play than the latter. Whether these differential emphases would be maintained in the context of more educational, or "serious" game play, warrants further exploration.

As noted above, the participants evaluated the game fairly highly. Not surprisingly, the students who liked the game more showed better performance. Better performance also was associated with greater reference to impasse, game cues, and game rules indicative of active efforts to master the game during the course of play. Among those students who identified as frequent players, better game performance was also associated with reference to impasse comments, insight, and game rules, also indicative of active problem-solving during the course of game play. These findings are consistent with those found among an adult population whereby greater reference to these types of comments was found over time, independent of their relatively poor evaluations of the game (see Blumberg et al., 2008).

Overall, our study provides an initial impression of children and adolescents' self-reported construction of game play over time and developmental differences in that construction among an age range that is becoming renowned for its keen interest in recreational media. Our findings highlight strong emphasis on contemporaneous behaviors and actions initiated by players in response to the game. However, they also elucidate behaviors typically associated with problem-solving indicative of video game play as a potent context in which to examine children and adolescents' cognitive development.

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