



## Original article

## Fostering Engagement in Health Behavior Change: Iterative Development of an Interactive Narrative Environment to Enhance Adolescent Preventive Health Services



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## A B S T R A C T

**Purpose:** Accidents and unintentional injuries account for the greatest number of adolescent deaths, often involving use of alcohol and other substances. This article describes the iterative design and development of Interactive Narrative System for Patient-Individualized Reflective Exploration (INSPIRE), a narrative-centered behavior change environment for adolescents focused on reducing alcohol use. INSPIRE is designed to serve as an extension to clinical preventive care, engaging adolescents in a theoretically grounded intervention for health behavior change by leveraging 3D game engine and interactive narrative technologies.

**Methods:** Adolescents were engaged in all aspects of the iterative, multiyear development process of INSPIRE through over 20 focus groups and iterative pilot testing involving more than 145 adolescents. Qualitative findings from focus groups are reported, as well as quantitative findings from small-scale pilot sessions investigating adolescent engagement with a prototype version of INSPIRE using a combination of questionnaire and interaction trace log data.

**Results:** Adolescents reported that they found INSPIRE to be engaging, believable, and relevant to their lives. The majority of participants indicated that the narrative's protagonist character was like them (84%) and that the narrative featured virtual characters that they could relate to (79%). In the interactive narrative, the goals most frequently chosen by adolescents were "stay in control" (60%) and "do not get in trouble" (55%).

**Conclusions:** With a strong theoretical framework (social-cognitive behavior change theory) and technology advances (narrative-centered learning environments), the field is well positioned to design health behavior change systems that can realize significant impacts on behavior change for adolescent preventive health.

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IMPLICATIONS AND  
CONTRIBUTION

This article describes the iterative development of Interactive Narrative System for Patient-Individualized Reflective Exploration (INSPIRE), leveraging 3D game engine and interactive narrative technologies, to engage adolescents in reducing alcohol use. INSPIRE is designed to serve as an extension to clinical preventive care. Adolescents reported that they found INSPIRE to be engaging, believable, and relevant to their lives.

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As the majority of morbidity and mortality during adolescence is preventable [1], technology-rich models of behavior change offer significant transformative potential to improve health. Accidents and unintentional injuries account for the greatest number of adolescent deaths, often involving use of alcohol and other substances [2]. Approximately 33% of U.S. adolescents use alcohol and 18% report binge drinking (consuming 5+ drinks within about 2 hours) [3]. Primary care visits present a key opportunity for improving adolescent health through preventive screening and counseling. While a growing evidence base supports the efficacy of clinical preventive services, and practice guidelines recommend delivering preventive services to adolescents across a range of risky health behaviors [4–6], evidence for changing adolescent behavior is limited with mixed results [7–12].

There is considerable momentum behind advancing integration of digital health technology to enhance the efficiency and effectiveness of the clinical encounter [13–15]. Health information technologies can play a prominent role in exchanging health information and providing access to health advice [11,14,16,17], encouraging adolescents to think about their health, enhancing readiness to interact with providers, and identifying important risk factors to facilitate delivery of preventive services [8,18–20]. Adolescents are acceptive of digital technologies [21,22], including modules for preventive screening [23], and there is accumulating evidence of the effects of digital health interventions on behavior [24–29] as they can be designed to assess an adolescent's risk and provide a convenient, individualized means for informing, enabling, motivating, and guiding individuals to make changes in their lives [28,30,31]. There is small but accumulating evidence of the effects of computer-based primary care interventions for reducing alcohol use [8,32]. However, these behavioral instruments are primarily utilized as screening tools to prime provider discussion within the clinic but are not designed to be integrated with personalized behavior change tools that extend the reach of the clinician.

Recent years have seen growing interest in using computer games to enhance and extend the delivery of health-care services [33–37]. Games for health provide interactive gameplay experiences directed toward improving users' ability to reduce risk behavior, prevent disease, adhere to treatment plans, benefit from therapies, and navigate health-care systems [33–36]. Games can be widely accessed through mobile phones, tablets, personal computers, and home consoles, providing capacity to engage adolescents in preventive health interventions across a range of settings and time spans. Despite this promise, relatively few game-based health interventions have been based on established theories of behavior change [28].

An important class of games for adolescent preventive health is narrative-centered behavior change environments. Narrative-centered behavior change environments embed health interventions within interactive story scenarios that are realized with 3D commercial game technologies [38]. In contrast to linear narrative media such as text, animation, and film, interactive narrative technologies enable youth to become active participants in unfolding storylines [39]. Interactive virtual worlds emulate real-world problem scenarios encountered by adolescents, introduce virtual characters with whom adolescents can identify, and naturalistically integrate elements that foster intrinsic motivation and emotional involvement [40].

This article describes the iterative design and development of Interactive Narrative System for Patient-Individualized Reflective Exploration (INSPIRE), a narrative-centered behavior change environment for adolescent preventive health-care focused on alcohol use. INSPIRE is designed to serve as an extension to clinical preventive care, engaging adolescents in a theoretically grounded intervention for health behavior change by leveraging the dual mechanisms of interactive narrative and 3D game technologies. This article also describes how principles from social-cognitive theory are operationalized to create an interactive narrative environment that promotes adolescent health behavior change. Youth were engaged in all aspects of the iterative, multiyear development process to inform key features of INSPIRE, including the cast of characters, virtual setting, interactive storyline, and gameplay mechanics. This was accomplished through a series of focus groups and small-scale pilot sessions which investigated adolescent engagement with a prototype version of INSPIRE using a combination of questionnaire and interaction trace log data.

Please see Figure 1 for the INSPIRE Iterative Development Model.

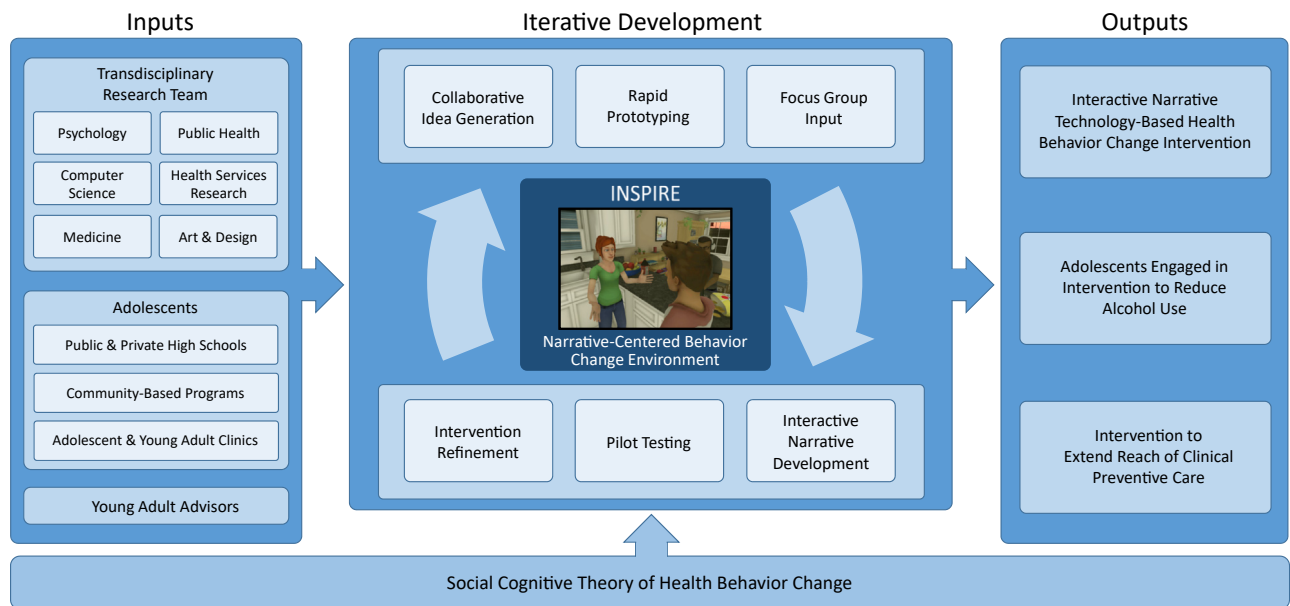
### INSPIRE Narrative-Centered Behavior Change Environment

A key objective of INSPIRE is to enhance adolescents' knowledge, personal efficacy, and skills through providing opportunities to practice strategies for reducing risky health behaviors. The game encourages players to set goals, adopt problem-solving strategies, and reflect on their observed outcomes to adjust their future behavior to better align with their self-selected goals. In INSPIRE, players "re-live" the events and decisions by a cast of virtual characters while at an evening high school party that involved alcohol use (Figure 2). Adolescents become active participants in a dynamically unfolding story that addresses issues of peer pressure, social norms, consequences of alcohol use, and strategies to avoid using alcohol. The outcomes for the protagonist, their friends, family members, and the storyline are actively shaped by the player's decisions.

INSPIRE was developed with the Unity game engine. Used widely in the commercial game industry, Unity is a game development environment that supports multiplatform deployments, enabling INSPIRE to be widely accessed via personal computer (Windows and MacOS) or tablet (iOS and Android). Although INSPIRE's problem scenarios are focused on addressing risky behavior involving alcohol use, a foundational component of INSPIRE is a generalizable software infrastructure that has been developed to enable the implementation of interactive narrative-based health behavior change interventions. Specifically, the design and development of INSPIRE has seen the creation of methods, technologies, and tools for creating believable 3D characters, realistic virtual environments, branching storylines, interactive conversational dialogues, and a range of in-game scaffolding features to support adolescent self-regulation and mastery learning, which can be readily translated to other contexts and areas related to adolescent health behavior change.

#### *Theoretically grounded interactive narrative design*

INSPIRE is grounded in social-cognitive theory for health behavior change [30]. Within social cognitive theory, beliefs of personal efficacy are central to mechanisms of human agency



**Figure 1.** INSPIRE Iterative Development Model.

[41]. Personal efficacy—beliefs in one's capability to organize and execute specific courses of action—plays a pivotal role in determining behavior across diverse domains. Perceived self-efficacy is a strong predictor of behavior, as people tend to avoid activities that they believe they cannot carry out and engage in activities they judge themselves capable to handle [42,43].

Mastery experiences are the key way of instilling a strong sense of efficacy. Players develop self-efficacy by mastering a series of increasingly challenging scenarios to explore alternate strategies for handling situations in the branching storyline. Self-efficacy can also be instilled and strengthened by vicarious experiences, such as modeling behaviors of others, especially those whom one admires or identifies with. While learning by doing requires shaping individual actions through repeated consequences, in observational learning a single model can transmit new ways of thinking and behaving simultaneously to a great number of people in different places. Through INSPIRE, adolescents encounter opportunities to learn vicariously through behaviors that are modeled by virtual characters in the narrative-centered behavior change environment. The interactive narrative has been designed to foster increased self-regulation, a key








component of social cognitive theory, which includes emphasizing the distinction between thinking fast (emotional and reactive) and thinking slow (deliberate and logical) [44], setting and monitoring healthy goals, gaining strategic knowledge (ways of refusing alcohol) and declarative knowledge (the risks and potential consequences of consuming alcohol), and reflecting upon prior decisions.

*Enabling vicarious learning.* Within INSPIRE, adolescents interact with a diverse cast of virtual characters (Table 1). The characters model a broad range of health behaviors to support vicarious learning through offering strategies, teaching about challenging situations, and guiding the player in practicing skills and providing feedback. The cast includes seven characters that have been designed to be relatable to the players and satisfy several objectives: believability and narrative “interesting-ness;” diversity across gender, ethnicity, physical body shape, personality, and socioeconomic status; feasibility for high-quality realization within a 3D interactive narrative environment; and capacity to support the health problem-solving scenarios outlined in the INSPIRE plot. Concept art, 3D models, textures, animations,



**Figure 2.** Screenshots from the INSPIRE narrative-centered behavior change environment.

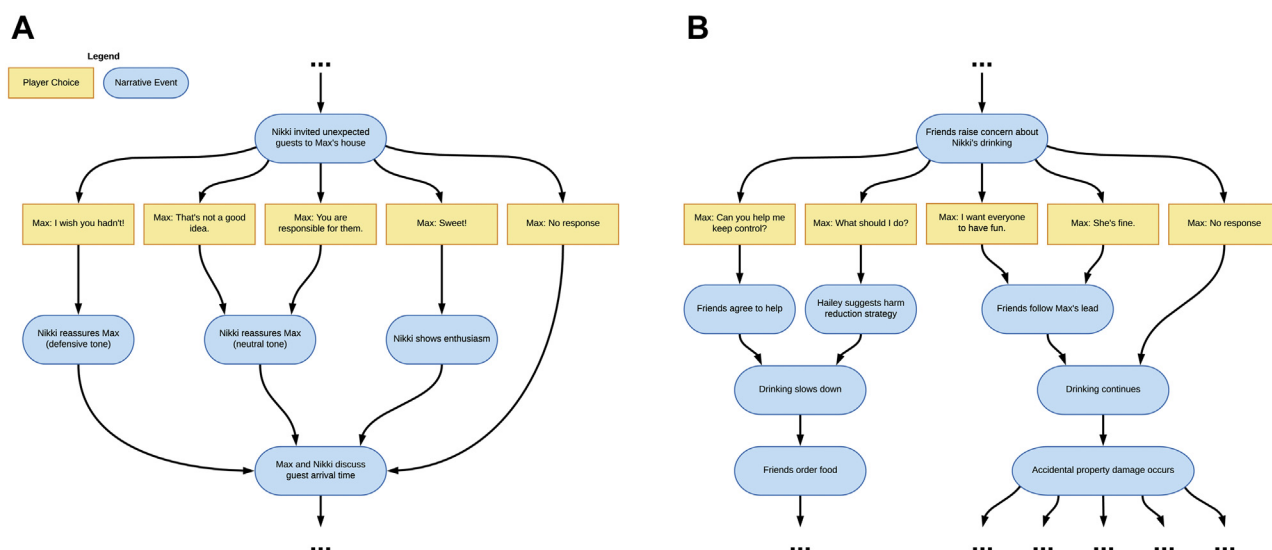
**Table 1**  
INSPIRE cast of characters

						
Name Max Age 16 Role Host of the party. Has a crush on Hailey.	Name Mia Age 11 Role Max's younger sister. Stays home during the party after a sleepover is cancelled at the last minute. Max discovers she is missing the morning after the party.	Name Jay Age 16 Role Close friends with Max. A popular and charismatic musician. Open to using alcohol, although he is receptive to Max's positive influence should the player choose to direct Max to refrain from drinking.	Name Nikki Age 16 Role Close friends with Max. A basketball player who likes to have a good time. Has a reputation for partying, and at times, lacks self-control in social situations.	Name Hailey Age 17 Role Max's crush. Serves as a positive role model in the story, demonstrating effective alcohol refusal strategies and prosocial behaviors.	Name Jeff Age 18 Role Older teen who graduated from high school the year before. Not working or in school, and appears to be content with his current lack-of-direction in life.	Name Lily Age 15 Role Younger teen who is excited about the prospect of attending a party involving older teens. Lacks experience with alcohol and shows a strong desire to be liked and popular.

personas, interpersonal relationships, and detailed dialogue were created and iteratively refined based on feedback through successive series of focus groups and pilot tests with adolescents.

*Providing practice opportunities for developing mastery.* The narrative design of INSPIRE blends branching dialogues and environmental storytelling features to create interactive narrative experiences that afford players meaningful agency while ensuring that a core set of narrative milestones are presented to every player, setting up varied opportunities to practice strategies for reducing risky health behavior.

Adolescents encounter a series of problem scenarios within INSPIRE that are realized through interactive branching conversations with virtual characters. During each problem scenario, players are given a set of 2–4 options to choose from, as well as a timer, which requires the player to actively assess the situation, evaluate alternate courses of action, and make decisions under time pressure. Players' decisions influence the short- and long-term reactions of other computer-controlled characters, and ultimately, the outcomes of the narrative. Problem scenarios in INSPIRE address topics such as uninvited guests arriving to a party, responding to peer pressure to



**Figure 3.** INSPIRE branching narrative structure examples.



consume alcohol, managing risky alcohol use by another peer, and handling an accident that has resulted in physical property damage. Please see Figure 3 for examples of branching narrative structures in the INSPIRE storyline.

Figure 3 shows a pair of branching narrative structures excerpted from the storyline of INSPIRE's first episode. In the first example (Figure 3A), the player responds to a scenario in which a group of unexpected guests has been invited to the home of the protagonist Max. Depending upon the player's choice, the short-term reaction of the computer-controlled character who invited the guests is different, but ultimately, all branching paths converge to the same storyline: the unexpected guests will arrive at the house. In the second example (Figure 3B), the player responds to a scenario in which several computer-controlled characters express concern about a peer's drinking behavior. In this case, the player's response has long-term consequences, producing a fork in the storyline that branches further and leads toward qualitatively different plot outcomes. The problem scenarios in INSPIRE provide practice opportunities for adolescents to gain experience in selecting problem-solving strategies (e.g., goal setting, evaluating options); observe models of healthy behaviors related to alcohol use; analyze tradeoffs between different courses of action; observe the consequences of individual and group decisions related to alcohol use and avoidance; correct misconceptions about social norms related to alcohol use; and reflect on connections between virtual experiences and real-world life.

*Maintaining engagement and connecting to adolescents' lives.* INSPIRE's story events take place in the protagonist's house. The urban/suburban setting is realized as a 3D virtual environment, which can be freely explored throughout the interactive narrative that is designed to provide a naturalistic stage for adolescent problem-solving and decision-making in the context of a party among high school students. The virtual house's style, layout, and décor were created to have the appearance of a realistic, lived-in house that adolescents could recognize and identify as authentic. Throughout the design and development of the environment, it was critical to create 3D models and textures that were sufficiently optimized to run on a diverse range of hardware platforms to facilitate multiplatform deployments and eventual integration with clinical care.

*Scaffolding self-regulation.* INSPIRE features several in-game tools to support adolescents' self-regulatory processes during

problem-solving in the narrative-centered behavior change environment. Specifically, software user interfaces were created for adolescents to set long- and short-term goals for the protagonist character, as well as monitor how their decisions aligned with the protagonist character's goals (Figure 4). The goal-setting interface consists of a sequence of two prompts. The first asks the adolescent to select three descriptions of "What's Important," (e.g., being a good friend, having fun, being responsible) to the protagonist character. The second, "Tonight's Goals," asks the adolescent to select three short-term goals for the evening (e.g., stay in control, have a chill night with friends, do not get in trouble) that apply to the immediate events of the storyline. The goals are intended to guide adolescents' decisions during dilemma-focused problem-solving episodes throughout the narrative.

A complementary user interface was designed to support adolescents in consulting and monitoring the protagonist's goals during decision-making episodes. When an adolescent is prompted to make a choice about how to respond to a difficult situation in the narrative, they are given the opportunity to consult the goals that they previously selected for the protagonist. The adolescent can also view a visual indicator of how past decisions align with selected goals, encouraging adolescents to monitor their own problem-solving and supporting self-regulatory processes.

A reflection tool has been designed to appear at the conclusion of adolescent interactions with the narrative-centered behavior change environment. The tool reinforces goals and decisions that adolescents selected within the interactive storyline to support self-regulation and facilitate generalization of behaviors to real-life situations. It also highlights strategies that other players have used in the virtual environment to handle challenging situations related to alcohol use and provides opportunities for adolescents to identify healthy behavior strategies that would be helpful in their own lives.

*Imparting knowledge about the effect of alcohol.* As adolescents explore the virtual environment in INSPIRE, they encounter virtual objects that can be picked up, manipulated, and visually inspected. The objects include food, cups, photographs, a journal, keys, newspaper, guitar, and hand-written notes, among others. Adolescents' interactions with these objects are optional, but visual cues (e.g., a glowing aura) help to make each object salient within the virtual world. These everyday virtual objects serve

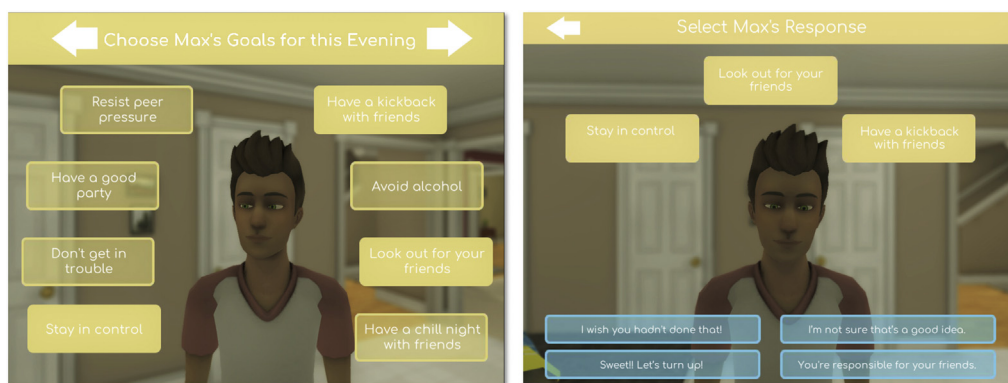


Figure 4. INSPIRE goal setting and monitoring features.

two purposes. First, they enhance the realism of the virtual environment and foster player agency by encouraging exploration of the environment. Second, the player can tap on the objects to reveal infographics that impart relevant knowledge about alcohol use and its consequences (Figure 5). For example, a virtual package of cookies includes a link to information about the caloric content of different types of alcohol. A virtual guitar provides access to an infographic about how alcohol affects the developing adolescent brain. There are a total of 13 virtual objects that can be examined by players in the first episode of INSPIRE, and five of the objects contain links to factual information about the effect of alcohol use.

#### Interaction trace log data

Most research on user engagement with health technology has relied upon subjective measures, such as self-reports, questionnaires, and interviews [45]. A key affordance of narrative-centered behavior change environments, such as INSPIRE, is the generation of interaction trace log data, which captures how adolescents select and enact behavior change-related decisions within a virtual environment. As adolescents explore INSPIRE, detailed logs of their in-game behaviors are time-stamped and recorded. These logs capture user actions at the event level, providing a granular view of adolescents' problem-solving and self-regulatory processes within the behavior change environment. System events that are initiated by the INSPIRE software are also time-stamped and logged. (See Table 2 for example user actions and system events that are logged by INSPIRE.)

Several log event types include additional attributes that are specific to the particular event. For example, the software records when an in-game tool (e.g., goal setting, knowledge infographic) appears on-screen, when it is closed, and how long it is open. When the player selects a conversational branch to influence the storyline, information about which virtual character was spoken to, and which conversational branch was chosen, are also logged. By logging data at this level, it is possible to reconstruct a detailed account of how adolescents spent their time engaging with the narrative-centered behavior change environment and produce descriptive statistics that summarize adolescent's usage.

#### Iterative development process

All the components of INSPIRE described previously were developed with significant input from adolescents through focus

groups and pilot testing to inform iterative cycles of design and feedback. The development of INSPIRE has been a collaborative, transdisciplinary process, with continuous input from psychologists, computer scientists, public health practitioners, pediatricians, and health services researchers over 4 years, from the conceptualization through pilot testing. Adolescents were engaged throughout the development of the project, through focus groups and pilot testing, as well as attendance at ongoing research team meetings as youth advisers. The following is a more detailed description of the methods used to gather feedback and key findings that informed the development and refinement of INSPIRE.

#### Focus Groups

Between 2014 and 2018, our research team conducted 21 focus groups that involved a diverse sample of 145 adolescents ranging in age from 14 to 19 years with the majority of participants between aged 15 and 17 years, the target age of the INSPIRE intervention. Focus groups consisted of six to eight adolescents of mixed gender. A subset of focus group participants attended more than one focus group over the course of the development process, as the adolescents were invested in providing feedback on iterative changes over time. These adolescent participants, who were 15 years old when they first participated in focus groups, provided feedback until they were seniors in high school (17–18 years of age). During pilot testing, we also recruited adolescents who were 14–15 years of age to interact with INSPIRE for the first time.

Focus group participants included adolescents from public and private high schools throughout San Francisco as well as community-based after-school programs in San Francisco and Vallejo, California, serving ethnically and socioeconomically diverse populations including first-generation college-bound youth. Participants were recruited through one of the two ways. The first was via formal partnerships with community organizations serving primarily minority (Latinx or African-American) students. Specifically, before each focus group, program staff at the community organizations contacted adolescents to inform them about the opportunity to participate in focus groups and contribute their ideas to the development of INSPIRE. The second recruitment method was via word-of-mouth from prior focus group participants. Human subjects approval was received from institutional review boards at both University of California, San

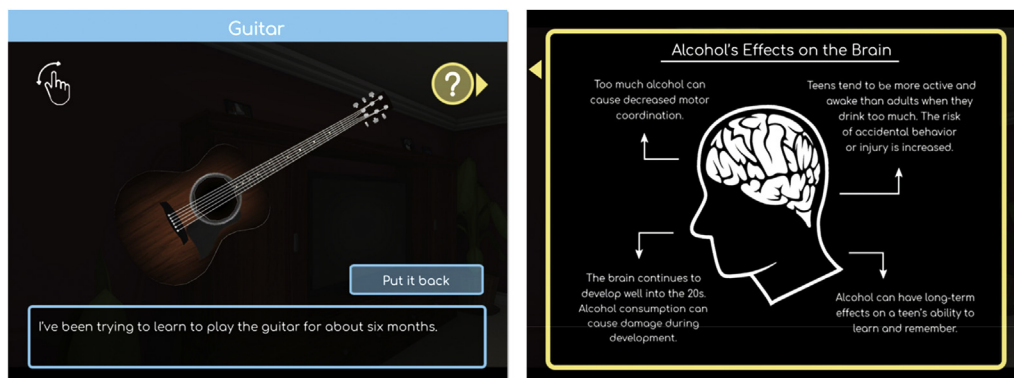


Figure 5. INSPIRE virtual object and accompanying infographic about the effect of alcohol on the brain.

**Table 2**

Examples of user actions and software events that are recorded in the INSPIRE interaction trace log data

Log type	Log description
User actions	Moved protagonist character to a new area of the virtual environment
	Initiated a conversation with a computer-controlled character
	Selected a conversational branch to influence the narrative storyline
	Picked up a virtual object to examine it more closely
	Selected a short-term goal for the protagonist character
	Closed a user interface showing a knowledge infographic
System events	Launched or closed the INSPIRE software application
	Displayed start menu for the INSPIRE software application
	Displayed conversational response of a computer-controlled character

Francisco, and North Carolina State University; written informed parental consent and adolescent assent was obtained from all participants, and focus groups were held at University of California, SF, and San Francisco Bay Area community centers.

The transdisciplinary team of psychologists, computer scientists, and pediatricians was present during all focus groups. The focus groups were moderated by the study PI, a licensed psychologist. Semistructured questions guided the focus group discussions, and per standard focus group procedures [46,47], the moderator remained neutral and sought input from all adolescents in each of the groups. Detailed notes were taken on all procedures and feedback. Following each focus group, the team convened to review themes that emerged and synthesized feedback to inform the iterative development of the game. Focus groups lasted approximately 90 minutes, and participants received a \$30 gift card.

Initial focus groups gathered input to gauge user interest; inform the storyline's design; develop and refine the narrative, cast of characters and dialogue; and tune the narrative environment's visual presentation style. Feedback provided on successive, intermediate versions of the virtual environment focused on software usability and design of game features, such as the embedded goal-setting features. Additional focus group feedback was collected to inform further refinements to the computer animations to "bring to life" the cast of virtual characters and optimize the branching dialogues and decision-making encounters in the narrative-centered behavior change environment.

Participants in the initial focus groups were integral to defining the cast of characters and the scenario. The research team introduced clips of various types of established games and characters to establish parameters such as level of realism and whether the game was played in the first person or third person. Characters were then designed based on participant input about physical and personality characteristics. Subsequent focus groups provided iterative refinement to the characters. A similar iterative process contributed to the party scenario, with initial focus group participants suggesting the story be set at a party and participants in later focus groups helping to hone the storyline and script.

#### *Focus group feedback*

**Environment and narrative.** Focus group participants found the interactive narrative design compelling, and they expressed a

preference for well-defined objectives, the mystery aspect of the plot (e.g., examining objects to gather clues and reconstructing past events by conversing with people at the party), and user agency and choice. Participants liked the plot concept of a protagonist protecting a more vulnerable character, such as a younger sibling. They also reported a preference for learning about the characters over the course of the game as opposed to reading character profiles at the outset.

Participants provided significant feedback to improve the ecological validity of the environment and narrative. Adolescents described hosting house parties, often involving alcohol, when parents were out of town. They felt that a party should start around sundown, and that it was typical to invite friends to the party via calling, texting one-on-one or texting to a group chat, and learning about a party via social media. Adolescents recommended that any "anti-drinking" attitudes on the part of the characters, and particularly "cool" characters, should be subtle as opposed to overt. They also provided feedback on the believability of drinking behaviors of the characters, and the way characters might handle a situation in which a friend had been drinking too much. They indicated that "beer pong" was common at parties and could be used in the game to highlight risky drinking behavior as well as strategies to avoid pressure to drink. As the interactive narrative evolved, participants reported that the experience of peer pressure around alcohol conveyed in INSPIRE felt authentic.

**Characters.** Participants preferred a diverse cast of characters with balance across gender, ethnicity, socioeconomic background, and life circumstances (e.g., single parent and two parent homes); well-rounded characters that were not stereotypical; characters they could identify with but not spend excessive time customizing; and a male protagonist because they thought males were more likely to host "house parties" as long as there was the opportunity to also play a female character in a second episode. They thought 16 years was an ideal age for most of the characters and that 11 was a realistic age for a younger sibling to be left at home with her older brother. To make the characters relatable, participants provided a significant amount of feedback on the overall appearance of the characters, including clothing style and fit, face and body shapes, eye and hair color, and hairstyles in relation to the characters' role in the game.

**Dialogue.** Discussions with youth revealed the delicacy of crafting dialogue. Participants stressed that use of slang should be realistic, generalizable across different groups of youth and used sparingly in the episode. Adolescents also offered advice on heightening the sense of drama at the narrative's outset, plot directions for later narrative situations, and a range of different choice points on how the protagonist might react to offers of alcohol and respond to nonplayer characters' drinking behaviors.

**Usability.** User-friendliness of the software was a high priority in the development process. Some participants initially reported that it was difficult to orient and navigate the player-controlled character within the virtual environment. This feedback informed the development of additional cuing elements, such as arrows, to indicate how players should navigate the virtual world. The pacing of the dialogue and the amount of time allotted to make conversational decision choices were also adjusted in response to adolescent feedback. Adolescents preferred limited time to make choices as this felt reflective of

real-life situations. Participants also provided feedback on integrating the game into primary care clinics, indicating that they would follow up to play INSPIRE at home if they were introduced to the game via a short video trailer at their doctor's office.

**In-game scaffolding.** Participants felt that features embedded in INSPIRE to support participants' self-regulatory processes (e.g., goal setting, monitoring) added value to the experience. They shared that the process for choosing and monitoring the goals was relatively easy and that choosing goals prompted them to think about their in-game decision-making and affected choices throughout the narrative. INSPIRE provided participants with a range of goal options to choose from, and these options were seen as relevant and realistic (e.g., "Don't get in trouble," "Have a good party").

### Pilot Tests

During the later stages of the design and development process, adolescents pilot tested a prototype of the INSPIRE interactive narrative to obtain self-report and trace-log data on user engagement with the virtual environment, including how adolescents selected and enacted behavior change-related decisions in the game.

### Participants and setting

Twenty diverse adolescents between the ages of 14 and 19 years were recruited to participate in pilot tests. (See Table 3 for

demographic characteristics.) All recruitment procedures and settings were consistent with those used for focus groups.

### Measures and procedures

**Self-report data.** Before interacting with INSPIRE on a tablet device adolescents completed an online questionnaire that included:

- Demographic variables: adolescent age, gender identity, and race.
- Alcohol use. Current use of alcohol was measured by quantity and frequency of use in the past 30 days [48].
- Video game-playing experience, such as how frequently do you play video games.

Adolescents interacted with INSPIRE individually by exploring the software on a tablet device. After interacting with INSPIRE, adolescents completed an online questionnaire about user engagement with the narrative-centered behavior change environment:

- Character relatedness. Assessed by two items:
  - o Adolescents were asked, "How much was Max like you?" (Max is the protagonist within INSPIRE), on a 3-point scale ranging from "not at all like me" to "very much like me"; and
  - o "There are characters in the game that I can relate to", on a 5-point scale ranging from "somewhat disagree" to "strongly agree".
- Satisfaction subscale of the User Engagement Scale [49,50]. The subscale incorporates items reflecting involvement and novelty, such as: "I continued to play the game out of curiosity" and "I felt interested in the game." Items were scored from strongly disagree (=1) to strongly agree (=5).

**Trace log data.** Trace log data enabled an understanding of how adolescents selected and enacted behavior change-related decisions within the narrative-centered behavior change environment.

**Knowledge.** Five knowledge objects were placed within the virtual environment for players to tap in order to discover and explore (i.e., package of cookies, guitar, solo cup, liquor bottle, and keys) information about alcohol use and its consequences to facilitate increased knowledge of risks associated with alcohol use.

**Goal setting and decision-making.** As described in the "Scaffolding Self-Regulation" section, at the outset of INSPIRE, adolescents identified "What's Important" to the protagonist character as well as the short-term goals for the evening within the interactive narrative. As they progressed through the interactive narrative, adolescents had to navigate scenarios related to alcohol use and peer pressure. At these junctures, adolescents were provided with several options that aligned with various strategies (e.g., declining alcohol, generating alternatives to drinking) and prompted to make choices about how to proceed.

The version of INSPIRE used in pilot testing included goal setting and monitoring tools. As it did not yet include an implemented version of the in-game reflection tool, no results

**Table 3**

Means, standard deviations, or percentages for demographic characteristics, alcohol use, and general video gaming usage for adolescents participating in three pilot tests (N=19)

Adolescents' characteristics and alcohol use	Mean or %
Age	16.6
Gender	
Female	53%
Male	42%
Transmale/transboy	5%
Race	
Asian	16%
Asian, white	11%
Black or African-American, white	5%
Hispanic or Latino	37%
Hispanic or Latino, white	5%
Native Hawaiian or Pacific Islander	5%
White	21%
Alcohol use	
Ever used alcohol	61% Yes
Used alcohol past 12 months	62% Yes
Past 30 days	33% Yes
Play online video games (yes)	56%
Playing frequency	
Not at all	5%
Rarely	37%
Occasionally	32%
Frequently	16%
Very frequently	11%
Devices most often used	
Personal computer	33%
Tablet	6%
Smartphone	28%
Home video game console	22%
Handheld game console	11%



are reported about interactions with the reflection tool functionality.

## Results

### Alcohol use

One-third (33%) of the adolescents endorsed alcohol use in the past 30 days.

### Video game use

Adolescents most often used a personal computer (33%) or a smartphone (28%) for video gaming. In addition, a majority (56%) of youth reported having experience with playing online video games.

### Engagement

Trace log data indicated that adolescents finished the game in an average of 20 minutes, ranging from a minimum of 17 to a maximum of 29 minutes.

**User engagement.** Engagement reflects user satisfaction (see Table 4), a 7-item subscale of a comprehensive user engagement scale created by O'Brien and Toms [51]. Adolescents reported a mean score of 3.57 (standard deviation = .90) on a 5-point scale, with average item scores ranging from a low of 3.37 (I would recommend this game to my friends and family, and The gaming experience was fun) to a high of 4.05 (I felt interested in the game).

**Character relatedness.** The majority of participants indicated that the protagonist was either somewhat or very much like them (84%) and that the narrative included virtual characters that they could relate to (see Table 4).

**Table 4**

Percentages, means, and standard deviations for INSPIRE engagement questions for adolescents participating in three pilot tests (N = 19)

Character relatability	% Participants
How much was Max like you?	
Not at all like me	16%
Somewhat like me	74%
Very much like me	10%
There are characters in the game that I can relate to?	
Somewhat disagree	16%
Neither agree nor disagree	5%
Somewhat agree	68%
Strongly agree	11%
User engagement	Mean (SD)
Satisfaction subscale	3.64 (.94)
I continued to play the game out of curiosity	3.89 (.68)
I felt interested in game	4.05 (.71)
The content of the game incited my curiosity	3.79 (.79)
The gaming experience was rewarding	3.42 (1.07)
Playing the game was worthwhile	3.58 (1.07)
I would recommend this game to my friends and family	3.37 (1.12)
The gaming experience was fun	3.37 (.96)

SD = standard deviation.

### Goal setting and decision-making

The goals most frequently chosen by adolescents were “stay in control” (60%) and “do not get in trouble” (55%) (see Figure 6). Data showed that adolescents used a variety of strategies to achieve their goals (see Table 5). For example, nearly all the participants who chose “stay in control” as a goal chose to recruit reliable friends to help them stay in control (90%) during relevant problem scenarios in INSPIRE. Furthermore, while just 15% of participants chose “avoid alcohol” as a goal, the majority of adolescents chose to decline alcohol at some point during the game (17 out of 20; 85%). Adolescents used strategies such as suggesting alternatives to drinking, expressing hesitation about or disinterest in drinking games, saying “I’ll pass for now,” when offered alcohol, or joking about the taste of alcohol.

### Knowledge

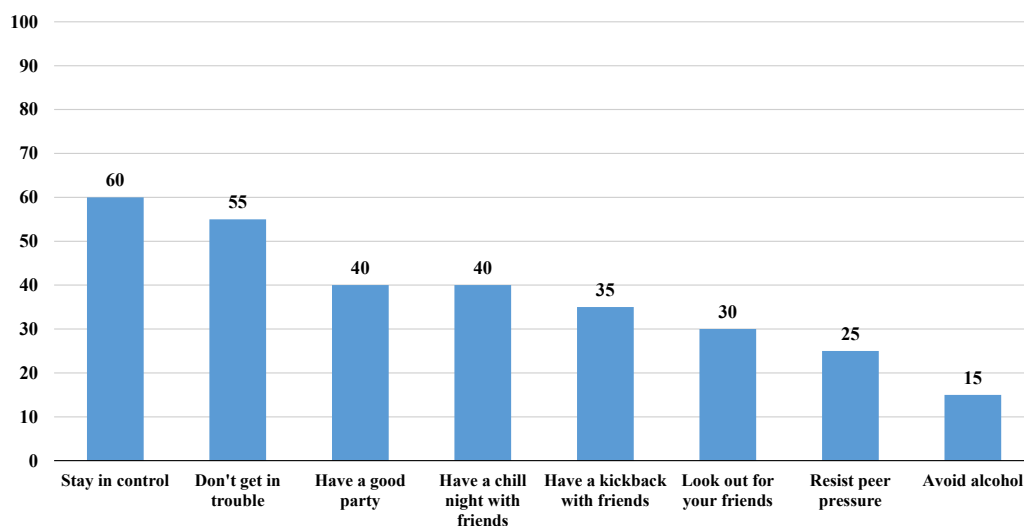
Trace logs indicated most adolescents consistently located and manipulated two of the five knowledge objects. The cookie and guitar objects were clicked by 95% and 78% of participants, respectively. The cookie object was most frequently explored, with 75% accessing its infographic for an average of 9 seconds, and 40% examining the graphic multiple times. Conversely, fewer than half inspected the vodka bottle or keys. No participants accessed the solo cup object due to a software bug.

## Discussion

This article describes the iterative design and development of INSPIRE, a narrative-centered behavior change environment for adolescent preventive health care. Grounded in social cognitive theory, INSPIRE translates evidence-based principles for promoting health behavior change into an engaging gameplay experience for adolescents to extend the reach of the primary care clinician.

Pilot tests, utilizing computer trace-log data as well as self-report questionnaires to explore adolescents’ experience with the environment, indicate that adolescents found INSPIRE to be engaging, believable, and relevant to their lives. Adolescents also successfully used a range of strategies for avoiding alcohol use in INSPIRE. Future plans include incorporating additional problem scenarios with escalating difficulty to provide further practice opportunities for adolescents to develop mastery across a range of situations involving alcohol use and its effects. Additional data will also be collected to investigate which goals and problem-solving strategies are most frequently selected by adolescents during gameplay interactions with INSPIRE, as well as how adolescents engage with complementary scaffolding features, such as in-game tools for supporting monitoring and reflection during the narrative problem episode, which were not a part of the pilot test reported in this article.

Adolescents accessed fewer in-game objects than anticipated and spent less time examining the associated infographics designed to impact knowledge about the effects of alcohol use. This may be in part due to technological issues (as described previously); it may also suggest that modifications are needed to improve how INSPIRE imparts knowledge, including changes to the placement and salience of the virtual objects, as well as the incorporation of additional in-game incentives for examining infographic features.



**Figure 6.** Percent frequency of goals selected by INSPIRE focus group participants (N = 19).

In the next phase of the research, adolescents who endorse alcohol use will be introduced to INSPIRE through a brief introductory video trailer during their clinic visit and will have the opportunity to engage with INSPIRE interactive narratives at home on a personal computing device (e.g., laptop or tablet). Key theoretical constructs, such as the impact of INSPIRE on enhancing adolescents' knowledge, personal efficacy, and self-regulatory processes to avoid alcohol use, will be tested.

While a foundational component of INSPIRE is a generalizable software infrastructure that has been developed to enable the implementation of a wide variety of interactive narrative-based health behavior change interventions, INSPIRE was iteratively developed and piloted with adolescents from the SF Bay area. Thus, findings may not be generalizable to other populations. Adaptation of INSPIRE to other contexts or settings will require

adjustments to visual art and testing engagement with other diverse populations. As discussed previously, an additional limitation of our study is that the results measured are focused on outputs reflecting development and engagement with INSPIRE. Key outcomes, such as adolescents' changes in self-efficacy and alcohol use, have yet to be examined.

Adolescent substance use is a serious national problem [3]. New strategies are needed to increase behavioral health screening in primary care and to offer brief and effective interventions to extend the reach of the clinician. INSPIRE, designed to be integrated into primary care clinics to enhance preventive care and promote adolescent behavior change, was found to be engaging and relevant to adolescents' lives. With a strong theoretical framework (social-cognitive theories of behavior change) and technological advances (narrative-centered learning environments), INSPIRE holds the potential to realize significant impacts on behavior change for adolescent preventive health.

**Table 5**

Examples of adolescents' goals and choices for INSPIRE scenarios

Scenario	Goal		
	Stay in control	Don't get in trouble	Have a good party
Friend suggests playing beer pong			
% teens choosing each response:			
Suggesting playing video game instead	33	46	25
Saying, "I'm not into playing beer pong"	25	27	13
Saying, "Are you sure we should do that?"	17	9	13
Saying, "Aw, yeah!"	25	18	50
Friend offers vodka shots			
% teens choosing each response:			
Saying, "I'll pass for now"	67	64	25
Saying, "Vodka tastes like hand sanitizer"	8	9	25
Saying, "I guess I'll try some"	25	18	38
Saying, "Let's get down to business!"	0	9	13
Friend seems to be getting drunk			
% teens choosing each response:			
Asking someone to help control things	92	73	75
Asking, "What should I do?"	8	18	13
Saying, "I want everyone to have fun"	0	9	13

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