# Engaging and Entertaining Adolescents in Health Education Using LLM-Generated Fantasy Narrative Games and Virtual Agents

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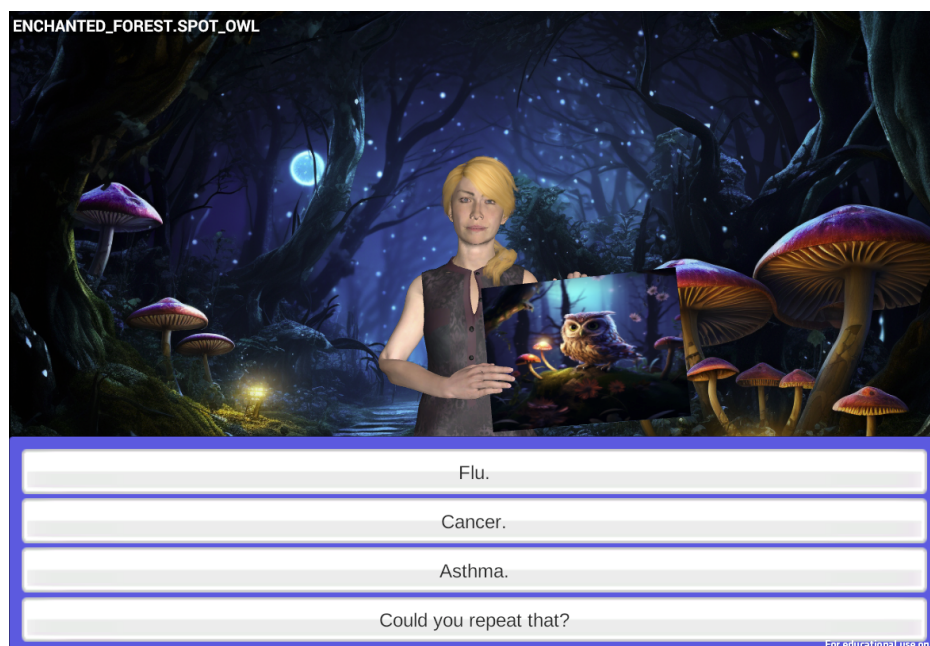Northeastern University
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**Figure 1: HPV Fantasy Narrative Game (Evelyn the Adventurer)**

## ABSTRACT

Games have been successfully used to provide engaging health interventions for adolescents. However, translating health education goals into a playable game has historically taken many person-months of effort, involving game designers, scriptwriters, and artists. This work presents an exploratory study into rapidly developing physician-validated health education games for adolescents using virtual agents and LLMs. We evaluated this approach in an intervention to promote Human Papillomavirus (HPV) vaccination among adolescents, as lack of knowledge and vaccine hesitancy contribute to suboptimal HPV vaccination rates.

We conducted a between-subjects randomized study comparing a fantasy narrative game to a non-gamified pedagogical virtual agent, with both interventions conveying the same HPV information. Among our study's 9-12-year-old adolescent participants, our findings demonstrate large pre-to-post improvements in HPV knowledge for both conditions. The gamified intervention showed higher engagement and entertainment than the pedagogical agent based on participant interviews, demonstrating that gamification enriched the educational experience for adolescents.

## CCS CONCEPTS

• **Human-centered computing** → *Empirical studies in HCI*; • **Information systems** → *Language models*; • **Software and its engineering** → *Rapid application development*.

## KEYWORDS

Gamification, Serious Games, Virtual Agents, Large Language Models (LLMs), ChatGPT, Image Generation, Midjourney, Vaccination Promotion, Adolescents

## 1 INTRODUCTION

Adolescence is a particularly important time for delivering many health interventions. This is when many health-related behaviors are established for adulthood, indicating it is the ideal time to begin promoting lifestyle health behaviors such as exercise and healthy nutrition [50, 59]. In addition, many interventions are recommended for adolescents, such as Human Papillomavirus (HPV) vaccination, a two-shot series for all adolescents between the ages of 9 and 14 that effectively prevents six different kinds of cancer [43]. Although HPV infection is a leading cause of cervical cancer and other HPV-related cancers, under half of 13-year-olds are fully vaccinated for HPV [44]. Adolescents' involvement in their health decision-making is crucial, as their desire to receive the HPV vaccine can positively influence parental consent, especially in cases of parental ambivalence or opposition to vaccination [16]. This emphasizes the necessity of directly educating adolescents about their health, including the benefits of the HPV vaccine, to foster their active participation in health decisions and improve outcomes. Despite the availability of effective vaccines, HPV vaccination rates remain suboptimal in many populations, necessitating innovative approaches for promotion. This is largely due to a widespread lack of knowledge about HPV, vaccine efficacy and safety misconceptions, and cultural or religious concerns, underlining the critical need for targeted education to dispel myths and support informed decisions about vaccination [1, 2].

In addressing these challenges, serious games have become a popular and effective medium for delivering automated health education and behavior change interventions to adolescents, promising a relatively low-cost way of reaching many individuals with a medium that can maintain adolescent engagement to educate and persuade [61]. One recent scoping review of 795 games for health articles found that most serious games in health are developed for children and young adults (40.9% vs. 3.4% for adults and 10.9% for older adults). Compared to face-to-face lectures or counseling, games have been found to improve learning outcomes by up to 40% due to their adaptation to the pace and interests of the player, their ability to reinforce information acquisition via situated

learning in simulated worlds, increasing self-confidence and self-efficacy through feedback and points mechanisms, and the active, participatory style of learning provided [31].

To provide adolescents with automated health education, we chose fantasy narrative games delivered by virtual agents for three crucial reasons: 1. narrative games provide a rich, immersive experience without complex game mechanics [46]; 2. use of multiple virtual agents for narration and role-playing further adds to engagement [23]; 3. narrative games and virtual agents reduce the need for live instructors or facilitators, thereby saving on ongoing personnel costs and logistical complexities [25, 64]. In addition, we have explored using Large Language Models (LLMs), specifically ChatGPT (vGPT-4), and Midjourney (v5.2), to expedite the creation of fantasy narrative games for adolescent health education. These models could substantially decrease the time and expense associated with the development and prove useful in creative brainstorming tasks such as game design and narrative composition [15, 28, 65].

In this work, we report our methodology for translating health education goals into a playable game designed for adolescents using virtual agents. Importantly, the methodology includes human-in-the-loop review methods by expert physicians to ensure veracity in the face of LLM hallucinations or fabrication. We demonstrate our methodology and the positive effect on adolescent learning by developing a game to promote HPV vaccination among adolescents. After describing our experience developing the game, we evaluate it in a randomized between-subjects game evaluation study, comparing it to a pedagogical agent that provides HPV vaccination facts as a virtual health educator conveying the same information. We hypothesize:

- **H1**: Both interventions will significantly improve knowledge and attitudes towards HPV and its vaccination.
- **H2**: Both interventions will enhance general vaccine knowledge and acceptance.
- **H3**: The narrative game will engage and entertain adolescents more effectively than the pedagogical agent.
- **H4**: The narrative game will more significantly increase the intent to seek HPV vaccination than the pedagogical agent.

## 2 RELATED WORK

### 2.1 Games for Health

The use of games in health is an increasingly popular area of research, tapping into the potential of serious games as entertainment and a tool for improving health outcomes. While serious games span various domains, including education, well-being, and healthcare, they possess a unique potential for positively impacting health and wellness [14, 22, 33]. Based on a comprehensive review of games for health, the classification of serious games reveals three distinct focuses: entertainment, health, and health acquisition and medical skills [62]. These classifications can include games that range from Dance Dance Revolution, aimed at physical exercise as a bonus [62], to simulation games like virtual dental implant training programs that focus explicitly on medical skills [38].

However, balancing the educational and entertainment aspects remains a challenge. For instance, the "Land of Secret Gardens"
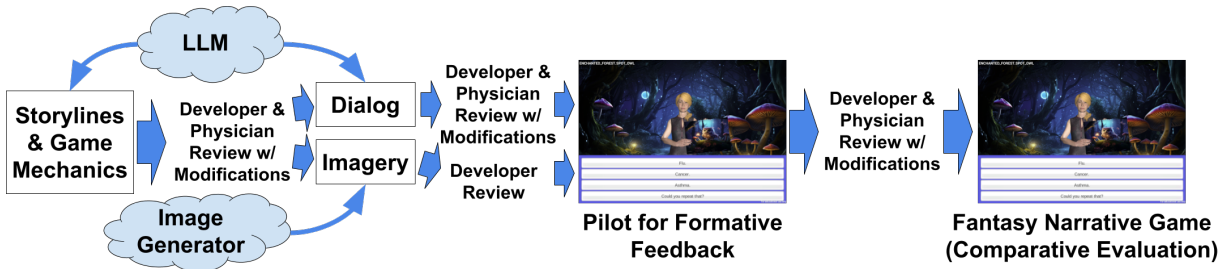
**Figure 2: Development Process for Fantasy Narrative Games using LLMs**

study, designed to increase HPV vaccination rates through mini-games, struggled to meld education and entertainment [11] effectively. While the game was engaging, its impact on vaccination rates was limited, suggesting a need for a more education-focused approach.

Moreover, the state of current research is not without its criticisms. A systematic review calls for a more rigorous methodology to enhance the quality of research in this domain [24]. This aligns with the conclusions from the comprehensive review, which recommends that future games either innovate by exploring underutilized features or focus on refining the most commonly used features for better efficacy [62]. The trend suggests that 3D interfaces with online connectivity on both PC and handheld platforms will likely dominate the field, enabling real-time interaction between therapists and players for more effective treatments. Informed by the existing work of games in health, our work seeks to balance the educational and entertainment elements in our online gamified intervention of a fantasy narrative game for adolescents.

## 2.2 Virtual Agents in Health Education

Virtual agents have been increasingly utilized in health interventions, combining conversational and empathetic nonverbal cues like hand gestures and facial expressions with spoken dialog. A growing body of research highlights the effectiveness of these agents as automated health counselors designed to facilitate health behavior change, with a particular focus on aiding individuals with limited health literacy [4, 6, 8, 9, 27, 36, 60]. Various domains have seen the successful deployment of these agents, including alcohol interventions [3, 66], psychotherapy [7], and substance use disorder treatment [40].

More recently, the role of virtual agents has expanded into vaccination education and promotion. Researchers have devised virtual agent systems aimed at increasing vaccination uptake by educating individuals about the benefits of vaccination [19, 45, 55], as well as by encouraging and informing others to get vaccinated [34]. These digital interventions have shown promise in outperforming traditional methods like pamphlets and brochures, which have had limited effectiveness in promoting vaccination and enhancing knowledge [32, 58]. For instance, web-based tailored interventions delivered by virtual agents have positively impacted informed decision-making around HPV vaccination, decreasing decisional conflict and increasing uptake [45]. Another pilot non-randomized trial found that computer-animated relational agents were more

effective at motivating discussions about HPV vaccination than traditional brochures [19].

## 2.3 Health Technologies for Adolescents

Recent advancements in health technology have shown significant promise in addressing diverse aspects of adolescent health. For instance, virtual agents have been successfully used in health interventions with adolescents where one agent was used in a year-long intervention to promote preconception care among 79 adolescent girls, demonstrating that almost all followed at least some of the agent's advice [5]. Conversational agents have also demonstrated their utility in culturally sensitive and stigmatized domains. Notably, the "AdolescentBot" chatbot has provided adolescents in Bangladesh with accurate sexual and reproductive health information, helping to correct misconceptions in an environment where such topics are often taboo [47]. In addressing responsible technology use, recent studies have engaged adolescents in co-design activities to develop tech-mediated strategies for screen-time management. This research has revealed that young users can offer valuable insights into designing solutions that foster responsible technology use [13]. Furthermore, digital health platforms, including text reminders and apps, have shown promise in increasing HPV vaccination awareness and intent [12].

## 3 VIRTUAL AGENT PLATFORMS

Our research leverages a generic software architecture to deliver interventions through simulated face-to-face dialog between users and virtual agents. The virtual agents in this platform are 3D-animated humanoid characters that engage users through both speech and nonverbal conversational cues, such as hand gestures and head nods, synchronized to their speech.

The architecture consists of several key components that make it robust and adaptable. We use a graphical rendering engine to create a visually engaging and interactive environment. We use a text-to-speech engine to convert scripted or dynamically generated text into lifelike vocalizations for natural and nuanced speech. Nonverbal behaviors are generated using the BEAT engine [10], adding another layer of realism and engagement to the virtual agents. The dialog engine operates on a hierarchical transition network-based scripting language and utilizes template-based text generation to manage participant interactions. Users can communicate with the virtual agents through multi-choice dialog options (Figure 1). We used our virtual agent platform to develop the NARRATIVE GAME and PEDAGOGICAL AGENT for HPV vaccination promotion.
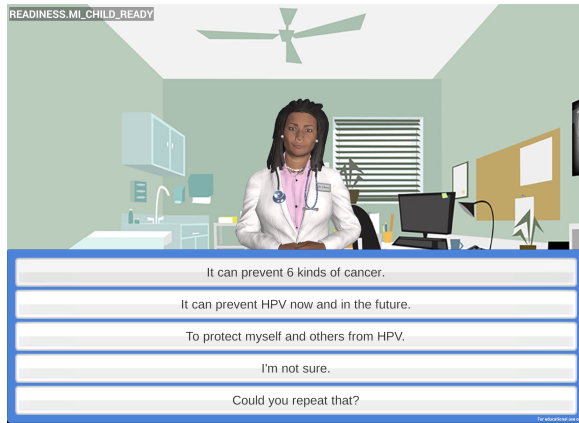
**Figure 3: Pedagogical Agent (Dr. Clara)**

## 4 METHODOLOGY FOR CREATING FANTASY NARRATIVE GAMES FOR HEALTH USING LLMS

We developed a fantasy narrative game for health using LLMs, following specific steps as shown in Figure 2. To achieve this, we used ChatGPT and Midjourney. Initially, we employed prompt engineering techniques, such as mixed prompting and providing instructions, context, and output indicators [18, 56], to align ChatGPT's responses with our specific requirements. This iterative process, supported by developer and physician expert reviews, helped us refine storylines and game mechanics suitable for our target audience. We used ChatGPT to co-create the game's dialog based on detailed summaries and guidelines of the game's storyline and mechanics. We repeatedly prompted the system to generate sufficient dialog options, ensuring the content was engaging and appropriate for adolescents. Our team reviewed and refined the generated dialog for accuracy and relevance. Inaccuracies were identified, such as suggesting medicinal plants as remedies against HPV and overstatements about the vaccine's efficacy and dose schedule. We used Midjourney to create background scenes and images of story creatures using prompts derived from ChatGPT's descriptions and dialogs. This approach, called *"prompt writing"*, is the ability of LLMs like ChatGPT to generate prompts that can help produce AI art in other AI platforms [54], in our case: Midjourney.

This approach to game authoring, using LLMs, was very efficient. ChatGPT required minimal prompting to generate viable storylines, game mechanics, and dialog, with 60.4% of its dialog contributions used in the final version without modifications. We confirmed the degree to which the LLM content was incorporated in the final game by computing the similarity between the ChatGPT-generated dialog and the final dialogs in the game (TF-IDF cosine similarity scores over 91%). This indicates that most of the LLM content was valid and appropriate, as judged by the physicians reviewing the dialog. However, we acknowledge the ethical considerations when using LLMs, as they involve potential risks related to data privacy, the propagation of biases present in training data, and the need for ensuring age-appropriate and culturally sensitive content in the context of adolescent health education [26, 57].

## 5 DEVELOPMENT OF THE NARRATIVE GAME AND PEDAGOGICAL AGENT FOR HPV VACCINATION PROMOTION

We developed both a PEDAGOGICAL AGENT and a NARRATIVE GAME to promote HPV vaccination in adolescents, both of which convey the same educational information about HPV and vaccination. The PEDAGOGICAL AGENT uses one virtual character that engages users in a simulated counseling session, focusing on providing factual information about HPV and vaccination (Figure 3). It offers a straightforward experience where users interact through multi-choice dialog options. The agent's dialog, adapted for adolescents from previous works on HPV vaccination counseling for adults [19], was refined by physician subject-matter experts to ensure age-appropriateness and accuracy. This adaptation emphasizes cancer prevention while avoiding detailed discussions on sexual transmission and genital cancers, in line with HPV vaccine communication literature for adolescents [21, 41, 42, 63]. The agent, "Dr. Clara," is set against a static cartoon background of a physician's office.

In contrast, the NARRATIVE GAME offers a more interactive and imaginative experience. The storyline of "The Quest for the HPV Vaccine" follows a player's journey in a fantasy world, aiding Evelyn the Adventurer (Figure 1) in a quest to help protect a village from HPV-related diseases by finding Dr. Clara and the HPV vaccine. It features three separate virtual characters with unique personas (Mary, the Narrator, Eveyln the Adventurer, and Dr. Clara, the Physician), enriching the storytelling with different character models and voices. The game's setting is visually dynamic, with background images that change to reflect different stages of the storyline, including a sky, a village, a forest, a cave, and mountains. Players can customize their character and role when meeting Evelyn when she asks, *"Who are you?"*. Given a list of dialog option responses, the player can choose between an Adventurer, Scientist, Mage, Warrior, or Healer. Additionally, players can choose from a list of dialog options to customize where they are from, what they are wearing, and their backstory. No visual differences are made based on players' character customization selections, but some agent dialog differs based on the player's selections. Supporting character customization improves engagement, even in a purely narrative sense, as players feel more immersed within the narrative [51].

The NARRATIVE GAME also includes riddles and quizzes integrated into the storyline, such as challenging players to solve HPV-related riddles posed by magical creatures, such as an owl who says, *"I am a sneaky virus called HPV. I can lay low or make my presence known to you. If I decide to cause trouble, what could I potentially lead to?"* (Figure 1), and battling against an HPV monster, personified as a dragon, who quizzes the player before letting them bring the HPV vaccine back to the village. There are some visual differences based on a player's choices, specifically during the forest section where the player has a choice to go left or right multiple times (e.g., Left. (Glowing Mushroom Path) or Right. (Whispering Willow Lane)). Lastly, when the player encounters Dr. Clara for the HPV vaccine, the player must engage in two rounds of Q&A about the HPV vaccine. Each question the player can choose has

an associated point value shown (e.g., *"At what age should the vaccination start? (20 points)"*). To successfully complete each round, the player must accumulate sufficient points by selecting the most important questions to ask. These interactive elements, such as riddles, quizzes, and points progression, make the learning experience more engaging and ensures the educational content is entertaining and memorable [30, 51].

## 6 PILOT STUDY

We conducted a pilot study with seven parent-adolescent dyads to obtain formative feedback on the NARRATIVE GAME. It targeted English-speaking adolescents aged 9-12 and their parents for recruitment via an online job listing site. Eligibility criteria included the parent over 18 years old, the adolescent between 9 and 12 years old, English proficiency, no completion of the HPV vaccine series, and access to a home computer with internet and video conferencing capabilities. Our institution's IRB approved this study, and participants were compensated. The protocol involved a one-hour Zoom session where adolescents interacted with the NARRATIVE GAME for 15-25 minutes under parental observation, followed by baseline and post-interaction surveys to gauge changes in HPV knowledge, attitudes, and vaccination intent. Parents also completed surveys, and a research assistant audio-recorded joint semi-structured exit interviews with parents and adolescents to gather 98.4 minutes of audio files for transcriptions of qualitative feedback on their experience.

**Findings:** The interviews revealed key insights into the strengths and weaknesses of the NARRATIVE GAME. Adolescents generally responded positively to the game, highlighting its engaging and interactive nature. Many adolescents reported that the game *effectively educated* them about HPV and positively influenced their attitudes toward vaccination. However, some adolescents found the *complexity of the agent utterances and riddles challenging and suggested simplification*. They also desired more *robust customization* options and improved *voice differentiation*. Parents also viewed the game positively, noting its appropriateness for the target age group and its educational impact. They found characters like Dr. Clara to be effective educational tools and felt more comfortable discussing HPV vaccination with their children after observing gameplay. The game's use of interactive media was well-received, balancing entertainment and education. However, additional concerns included the complexity and speed of certain game elements, which some felt could be challenging for younger players. Following this, we implemented several key modifications to the NARRATIVE GAME: we simplified the dialogs and riddles for greater accessibility, introduced more robust character customization options, improved voice differentiation for characters, expanded the educational content to include detailed information on vaccine side effects, and adjusted the game's complexity and speed for younger players.

## 7 COMPARATIVE EVALUATION STUDY

We conducted a randomized between-subjects experiment comparing the NARRATIVE GAME to the PEDAGOGICAL AGENT. Our institution's IRB also approved this study, and participants were compensated. Participants were recruited similarly to the pilot study and assigned to either group through block randomization. Outcome measures included HPV knowledge and attitudes,

HPV vaccine knowledge and attitudes, general vaccine knowledge and acceptability, intent to vaccinate, usability and satisfaction, engagement, and entertainment. To measure these, we used composite questionnaires adapted from [29] for HPV-related knowledge and attitudes, and from [39] for usability and satisfaction. Intent to vaccinate was assessed using Likert scale questions directed at adolescents and parents [35]. Through content analysis, we evaluated the perceptions of engagement and entertainment by coding transcripts from audio-recorded, semi-structured exit interviews with both parents and adolescents. This process involved analyzing 124.43 minutes of audio files using NVivo 12. During coding, we identified five major categories: engagement, entertainment, the balance between education and entertainment, comfort and confidence in discussing HPV with their parent or child, and appropriateness of the intervention for adolescents. Engagement was coded based on explicit mentions or inferred instances of adolescents demonstrating high engagement, characterized by heightened attention or active involvement. As for entertainment, our coding criteria focused on identifying clear signs or hints of adolescents enjoying themselves or experiencing a high level of enjoyment during the activity. Individual transcription instances of engagement and entertainment were then organized by the participant's assigned group and summed for comparative evaluation.

**Participant Demographics**: Thirteen parent-adolescent dyads participated in our study and were all Black or African American. All adolescents were 9-12, with the majority being 11 years old (46.2%) and predominantly female (76.9%). Most adolescents spoke English well (69.2%), had moderate computer experience (69.2%), and received zero doses of the HPV vaccine (zero-doses: 69.2%; one-dose: 30.8%). Parents had a mean age of 30.2 with a standard deviation of 2.78 and were mostly male (61.5%). Most parents had attained a Bachelor's degree or higher (61.5%) and had health insurance coverage (84.6%), but vaccination rates were relatively low for parents (76.9% unvaccinated).

**Findings:** We observed both interventions increased HPV knowledge and attitude (paired-t(12) = 2.31, p<0.05), HPV vaccine knowledge and attitude (paired-t(12) = 5.06, p<0.001), and general vaccine knowledge and acceptability (paired-t(12) = 2.79, p<0.05), with no significant differences between the groups in these areas. The intent to vaccinate also increased (Z = 2.25, p<0.05), but without significant difference between the interventions. Usability and satisfaction were similarly high in both groups against a neutral score of 4 (PEDAGOGICAL AGENT group single sample t(10) = 4.98, p<0.001; NARRATIVE GAME group t(12) = 4.11, p=0.0015), although no significant differences were found between them. The NARRATIVE GAME group, however, showed a significantly higher level of engagement (t(11) = 2.19, p<0.05) and entertainment (t(11) = 2.70, p<0.05).

When we asked parents how they feel about using games and interactive media such as this to teach adolescents about health-related subjects, they responded with (P7–Parent) *"I feel like it's an effective way and it tends to stick to the child's mind because of animated creatures."*, (P13-Parent) *"I think it's very good because it makes it more easier for a child to understand more about the HPV"*, (P3-Parent) *"I would say it's good. It's suitable because they pay more attention"*, and (P2-Parent) *"I totally agree with the concept because I*

*feel like at this time in the world, I think such games would resonate more with the kids"*. These quotes showcase how parents viewed the NARRATIVE GAME as both **engaging** and **appropriate for adolescents**.

Many adolescents and parents praised specific visual elements that contributed to the adolescent's overall **entertainment** with the NARRATIVE GAME game, such as the creature images, dynamic background, and multiple characters, (P2-Adolescent) *"It was fun, especially the mushrooms, the glowing mushrooms"*, (P9-Parent) *"I liked the change of areas and the characters"*, (P2-Adolescent) *"The characters were good...I loved talking to the characters!"*. Adolescents in the PEDAGOGICAL AGENT group also found the intervention enjoyable; however, they made significantly fewer references to particular instances or entertaining elements of the intervention, with most simply echoing a sentiment similar to that of (P1-Adolescent), who stated, *"For me, it was fun"*.

When we asked parents whether observing their child affected their **comfort and confidence in discussing HPV vaccination** with them, one responded (P10-Parent) *"It did affect me because I saw the excitement as he was playing!"*. When parents were asked about their thoughts on the **balance between entertainment and education** in the game, they responded with, (P12-Parent) *"Quite a balance...Since at the end of the day you have to give a response...you're not only be entertained, but you have to really hear what they said"*, (P10-Parent) *"I think it was well balanced...it was educational and it was fun because I saw the excitement in my kid"*, (P13-Parent) *"I think it was balanced...someone can have fun and at the same time he or she can be educated"*. Overall, parents viewed the NARRATIVE GAME as an effective intervention that balances the educational and entertainment aspects of the game, as well as a medium for which they became more comfortable and confident in discussing HPV vaccination with their child.

## 8   DISCUSSION & FUTURE WORK

The comparison of the NARRATIVE GAME versus the PEDAGOGICAL AGENT in educating adolescents about HPV vaccination yielded significant insights. Both interventions significantly improved knowledge and attitudes toward HPV and general vaccine knowledge and acceptance, affirming hypotheses H1 and H2. This aligns with prior research underscoring the positive impact of education on HPV knowledge and vaccine attitudes [17]. However, hypothesis H4, which suggested the NARRATIVE GAME would more significantly increase the intent to seek HPV vaccination compared to the PEDAGOGICAL AGENT, was not confirmed. This outcome might be attributed to the parental presence, potentially aligning adolescents' vaccination intent with their parents' perspectives, which did not show significant differences either [49]. Nevertheless, the study revealed that adolescents were more engaged and entertained with the NARRATIVE GAME, supporting our third hypothesis (H3) about the efficacy of gamified learning.

Furthermore, we explored the ability to use LLMs as brainstorming devices and co-creators of game content for adolescent health education. Given that most of the ChatGPT-generated dialog was utilized in the final game without any modifications and was highly contextually similar to the final physician-validated dialog, we believe LLMs could be a new way of rapidly developing games for

health education and urge further research to explore their capabilities. However, we occasionally found hallucinations, such as incorrect HPV information, which provides additional evidence for the necessity of human-in-the-loop approaches, especially in health education, that related work has identified as critical as well [20, 52]. Nevertheless, we plan to conduct future work on the use of LLMs in multi-party HPV education settings involving parent-adolescent dyads. Prior work has shown the benefits of involving both parties in HPV vaccination discussions [53], and the potential of integrating them into a collaborative HPV fantasy game with real-time speaker diarization via LLMs [37]. In addition, we believe a study devoted to solely evaluating the ease of use, safety, and time-savings of utilizing LLMs in creating narrative health education games for adolescents would provide valuable insights into optimizing the development process, potentially revolutionizing how digital health education content is created and tailored to specific audiences.

## 9   LIMITATIONS

Despite the positive results, our study was limited due to our small and homogeneous participant sample. This underscores the necessity for future studies to involve a larger and more diverse group of participants. Additionally, adolescent participants were evaluated while accompanied by their parents, which could have biased the results. Therefore, we plan to assess the impact of environmental factors on adolescents' engagement and health outcomes with the HPV fantasy narrative game, particularly in different educational settings. A parent's suggestion (P28-Parent) to implement the game in schools, where HPV education might be more effective in a gamified format, especially in under-resourced environments, guides this direction. In low-income schools, adding HPV vaccination to the health education curriculum would fall heavily on teachers who already report feelings of burnout [48]. Using a tool like our NARRATIVE GAME could alleviate their burden while providing specialized health education to students and parents.

## 10   CONCLUSION

We explored the efficacy of using virtual agent-based fantasy narrative games in health promotion for adolescents and using LLMs to develop these games rapidly. Our findings suggest that both the PEDAGOGICAL AGENT and NARRATIVE GAME interventions led to a significant increase in HPV and HPV vaccination knowledge and attitude, providing support for the effectiveness of both modalities in promoting HPV vaccination. Our study offers valuable perspectives for future research involving virtual agents and LLMs in the rapid development of narrative games to engage and entertain adolescents in health education.

## ACKNOWLEDGMENTS

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