# A Day in the Life of Jos: A Web-based Game to Increase Children's Digital Literacy

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## ABSTRACT
Digital literacy is an important educational topic because most children consume and create digital media regularly. We used procedural rhetoric to iteratively design an educational game for 11-13 year olds about digital literacy topics. We conducted three empirical user studies to evaluate the game's usability and effectiveness throughout the design process. Results from our summative study showed that children's digital literacy knowledge and intended behavior improved significantly immediately after playing the game and one week later. They also found the game usable, fun, and relatable. We present a case study of our design process, and use insights from our work to propose recommendations for designing children's educational games using procedural rhetoric.

## ACM Classification Keywords
K.3.2 Literacy

## Author Keywords
Persuasive games, Digital literacy, Children, Privacy, Security.

## INTRODUCTION
Recent statistics show that over 90% of youth are online [8,17,27]. Given these statistics, there is a need to educate children on how to behave safely online and improve their overall digital literacy [47]. Digital literacy represents the skills children need to create and consume media in the 21st century [26]. Games can be used to educate children about digital literacy issues, because they can allow them to practice safe behaviors before encountering them in the real world [23]. Children can also make different choices (good or bad) and see the consequences of their choices in the simulated environment. To be effective, games for attitude or behavior change should be designed in such a way that they convince the player that the desired behavior/attitude is correct [3,7]. Procedural rhetoric is a theory for designing such games [7]. Proposed by Ian Bogost, it states that an argument or claim (rhetoric) should be embedded in the mechanics of a game so that players discover the rhetoric by playing the game [7]. By discovering the argument through procedure (experience), players are more likely to believe it than if it was presented to them as information [7]. While procedural rhetoric has been used in commercial games, not much work has critically examined its effectiveness. Questions such as how procedural rhetoric can be used to create an effective game, and which game mechanics are ideal for embedding rhetoric remain unanswered. Our work attempts to fill some of this gap in the literature.

We used procedural rhetoric to design a game for improving the digital literacy of 11-13 year old children. Topics addressed in the game include cyberbullying, privacy, sharing, and authenticating information online. Procedural rhetoric is the underlying theoretical principle of our game, because of its experiential nature. This is especially important with digital literacy and the topic of security and privacy because the environment and risks are continually evolving. Children must be able to recognize threats or risky situations that they may never have encountered before and reason about the best course of action. It requires significant vigilance and awareness that comes from experience. A game using procedural rhetoric can help with providing some of this experience.

The game was designed in collaboration with our educational partner MediaSmarts, a national, not-for-profit charitable organization which promotes digital and media literacy in Canada [33]. The game is designed to be used in a classroom with assistance from teachers, and will be licensed to schools across Canada. Since digital literacy is part of the school curriculum, we felt that using the game in classrooms would be most beneficial for children [32,35–37,41,42]. However, designing games for classrooms presents additional constraints which must be considered in the design process. These include the limited play time available during a lesson, formal evaluation needs of teachers, and choosing educational content for the game [24]. Each of these constraints are addressed in our design process. We used a user-centered design process and evaluated the game at each stage of the process with a total of four user studies. Our summative study showed that children's digital literacy knowledge and behavior improved immediately after playing the game and after one week.

Our main contributions are: (1) Explicit application of procedural rhetoric to design a game for children, (2) Evidence of a persuasive game improving children's behavioral intent and knowledge, and (3) Recommendations for using procedural rhetoric to design persuasive games for children.



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## BACKGROUND

### Digital Literacy

Digital literacy represents the skills and competencies required to operate in the digital world, and includes functional and cognitive skills for consuming and creating media [15, 25, 26]. Topics include security, privacy, netiquette, cyberbullying, illegal activities, searching and verifying information, and using critical thinking to determine the authenticity of information [19, 25, 26]. Many governments, schools, and organizations have introduced policies and programs to increase the digital literacy of citizens and some educators argue that digital literacy should be mandatory in school [19, 20, 25, 29, 38–40, 43]. The US, Canada, and the EU have made efforts to incorporate digital literacy in school curriculums [29, 32, 35–37, 40–42]. In Canada, MediaSmarts has also developed digital literacy tools and games for classrooms [33].

Several games educate users about specific digital literacy issues [9, 33, 48]. The US Federal Trade Commission provides games to educate the public about privacy, online security, and identity theft [9]. Carnegie Cadets educates elementary school children about online safety, spam, and cyberbullying [48]. MediaSmarts designed the Jo Cool or Jo Fool quiz to teach 10-13 year olds about safe web browsing behaviors [31]. Designed in 2000, the quiz is still being used in schools but its content, design, and technology are outdated. An issue with these resources is that there are no public reports on whether they are effective at improving players' digital literacy.

### Procedural Rhetoric

Bogost [7] defined procedural rhetoric as the practice of using processes or mechanics to construct an argument in a game. This principle is useful in games that are trying to make a statement to the player, such as in educational games [7]. Games employing procedural rhetoric make their argument by embedding it within the rules of the game. As players interact with the simulated game world, they progressively discover the argument presented by the game. For example, Debt Ski [14] utilizes procedural rhetoric to educate young people about the dangers of excessive debt and teaches them financially responsible behavior. In the game, players control a piggy bank with the objective of increasing income and happiness [14]. Income is earned throughout the game and happiness is increased by buying merchandise. Towards the end of the game, players arrive at the conclusion that debt can be accrued easily and balance is needed between happiness (spending) and income. The power of procedural rhetoric is that players are more likely to believe an argument if they experience it for themselves in a simulation, compared to being told about it. Although procedural rhetoric was formally defined in 2007, researchers have used such strategies prior to that to create persuasive games for various application areas. These games used theories of persuasion from psychology or social sciences as their underlying theoretical framework. Since its definition, procedural rhetoric has been mostly used by independent game studios to create behavior change games [13]. However, the success of these games is measured by their popularity or usage, and not their effectiveness at changing the intended behavior. With the exception of a few, not much work in HCI has used procedural rhetoric explicitly to design and evaluate educational games [11, 12, 16, 45]. Without such work, the effectiveness of procedural rhetoric is unclear to designers, and they do not have access to insights on how to successfully apply procedural rhetoric to the design of new games.

#### *Use of Procedural Rhetoric in HCI*

Researchers have explicitly used procedural rhetoric to design behavior change games for homelessness, understanding Attention Deficit Hyperactivity Disorder (ADHD), energy conservation, and healthy eating. Spent is a game to increase positive attitudes towards the homeless [45]. Players are provided with $1000, with the goal of surviving for a month, where each day requires them to make difficult choices. By playing the game, players realize that homelessness is a matter of circumstances and not character [45]. An evaluation showed that affective learning improved after playing the game [45]. The game Drawn to Distraction facilitates understanding of ADHD among caregivers and adults [16]. It shows players that ADHD individuals have an increased drive to engage in immediately rewarding activities, despite knowledge of their long term harm [16]. A study showed an improvement in players' understanding of ADHD.

Doucet et al. designed a real-time strategy game to educate users about energy conservation [11]. Set in a post apocalyptic world, the player survives by defeating zombies. Positive energy behavior helps players survive and negative behavior jeopardizes survival. A study showed that players enjoyed the game and it improved their knowledge of sustainable energy use [11]. In Fitter Critters, a game to teach children healthy eating habits, players care for a virtual pet. They make choices affecting the health of the pet, and consequently learn about health and nutrition. Each choice has both positive and negative effects on the pet's well being, so players learn which choices are most beneficial [12]. A study showed that it was positively received by children and resulted in increased nutrition knowledge, positive attitudes toward healthy eating, and healthy eating self-efficacy [46]. Although Fitter Critter was evaluated in a classroom, it did not track student progress to help teachers incorporate the game into their curriculum.

The four games reviewed here show that procedural rhetoric can be used effectively to design different types of games for various application areas. However, they are different from our work because most of them were designed for adults and none were designed to be used in a classroom setting. Based on the experience of designing Fitter Critters, Ferrara proposed five guidelines for designing games using procedural rhetoric [12]. These include defining a core message for the game (P-G1), offering meaningful choices (P-G2), enabling self-directed discovery (P-G3), tying the message to strategy (P-G4), and keeping the simulation realistic (P-G5). With regards to the message, the game must be designed around a clear and concise statement of what the players should do or believe [12]. Games with the goal of winning should embed the message into the winning strategy, which will drive players efficiently towards the message [12]. The game should allow self-directed discovery of the message, which will give players a feeling of ownership and insight [12]. Meaningful choices

| Day | Scenarios |
|---|---|
| Cyberbullying | Sharing gossip, sharing funny video or photos of others, defending people being bullied, and dealing with online bullies. |
| Online tracking | Providing data to apps, deleting data online, phishing, browser and search engine histories. |
| Privacy | Using apps like Snapchat, sharing pictures without consent, using public computers, asking others to remove pictures, and managing your online reputation. |
| Sharing Online | Sharing pictures or videos of others without consent, copyright, dealing with a depressed friend, sharing private photos of yourself |
| Authentication | Verifying the authenticity of information on social media, wikis, and websites |

**Table 1:** Digital literacy topics addressed by the game

should be offered, and there should be benefits to making the wrong choice, which will foster exploration and discovery [12]. Lastly, the simulation should be realistic, giving it credibility and allowing players to apply the learned behavior in the real-world. We will use these guidelines as the basis for designing our digital literacy game.

A related research area, Persuasive Technology, uses methods of persuasion to influence behavior change. Although many children's educational games have employed persuasive technology, for example to encourage physical activity [1,5], learn math and computational thinking [4,22], and promote energy conservation [18], these do not make explicit use of procedural rhetoric as a method of persuasion.

## DIGITAL LITERACY GAME

Our goal was to design a game to educate 11-13 year old children about digital literacy issues, with a focus on privacy and security, including developing critical thinking skills about novel situations that they may face online. These children will likely have social media accounts soon, given that the minimum age requirement of most social media platforms is 13. The main message of our game is that life with digital media is complex, and the correct behavior is not always clear. However, we always have a choice and the choices we make have consequences (good or bad) on our personal and digital lives (P-G1). Given this, we used a-day-in-the-life approach to design our game, where players follow the main characters of Jo and Josie through a series of events in their daily life and help them make smart decisions online. The main characters are avid social media users, and reflect our target audience who are digital natives and use multiple electronic devices in their daily lives. By playing the game, children are able to see possible consequences of their choices in a simulation before they make them in the real world.

Since the game is meant to used in a classroom setting, an additional constraint was to keep the game short so that it can be completed as part of a lesson (typically lasting under 60-minutes) and foster discussion among students. It also needed to have measurable educational goals which can be used by teachers to evaluate students' performance. In collaboration with us, MediaSmarts specified the target audience, identified educational topics, and created content for the game. Figure 1 shows the opening screen of our new game, where the calendar represents a typical school month for the player. The game has five days which are active in the calendar and are highlighted in red. Days with a dark grey background have been completed by the player. As detailed in Table 1, each day addresses a different digital literacy topic, and includes five scenarios covering different aspects of the topic (for a total of 25 implemented scenarios). A short introduction and instructions on how to play the game are provided. To begin, players select a day from the calendar which directs them to the main screen for the day. The visual design is different for each day, reflecting the topic addressed by the day, and the page links to five related scenarios. Each scenario shows Jo or Josie going through a situation where they require the player's help in deciding how to behave safely.


**Figure 1:** Main screen of the Jo's game

Scenarios are text and graphic based, and are presented via a series of animations. At the end of a scenario, players are provided with three choices and have to pick the choice that Jo/Josie should make. Options reflect the choices children make in the real world, which have many grey areas between correct and incorrect behavior, sometimes with unexpected consequences. Each choice has different consequences on Jo/Josie's life, and players can see the consequences of their choices in the news feed component (Figure 2c), which acts as an aggregator of the characters' digital media platforms. Figure 2 shows part of a scenario. The scenarios are quite diverse, for example Josie working with a friend in science class, or the siblings playing an online game with friends. Scenarios in a day must be completed in temporal order. Progress is automatically saved when a scenario is completed, so players can return to the game to continue at any time. Players can replay completed days, which is useful if they want to see the outcomes of different choices. When replayed, the game score and the content of the news feed are adjusted accordingly.

### Choices

Choices in a scenario (Figure 2b) are the main mechanism of procedural rhetoric in the game (P-G2). By playing a day in the game, players experience the consequences of their choices on Jo/Josie's digital lives and come to realize the main message of the game (P-G3). We designed the choices to reflect the real world, so the correct choice was not always clear, requiring players to think critically of the choices and the situation. This design allows players to explore and discover the consequences of different choices. Players can take a risky


**(a)** Introduction screen **(b)** Choices screen **(c)** News feed showing the consequences

**Figure 2:** Scenes of a scenario in the game.

approach and pick all the "bad" choices, just to see their effects on Jo/Josie's digital lives, or they can try to pick the safest choices in each case, the consequences of their choices are immediately apparent on Jo/Josie's lives. Thus, the rhetoric of our game is reinforced through the user's choices.

### News feed and Navigation

The news feed displays results and consequences from the scenarios. It is a consistent element in the game, accessible from any screen, and allows players to review the consequences of their choices on demand, helping them reflect on the learned material. Players can display/hide the feed and can switch between Jo and Josie's feeds (Figure 2c). The news feed can also help players review their choices, which may encourage them to replay the scenarios and make different choices to explore different outcomes (PG3). For game navigation, we used an explicit control (Figure 2a, arrow on right edge) to transition between scenes in a scenario to accommodate children's different reading levels and speed.

### Scoring and Feedback

Players choose from three choices at the end of a scenario, and each choice is worth 0, 1, or 2 points. The total score for the game is always visible (Figure 1) and reflects how well the player is doing. After completing a scenario, players are told whether they made the most appropriate choice. Detailed feedback is provided after a day is completed, and explains the player's performance for the whole day. It shows their choices per scenario and associated score, then offers commentary and advice of better alternatives if appropriate (PG-4). This review screen allows players to reflect on their choices and the learned material, which aids in retention and application of the material to real world settings. Low scores in the game encourage players to redo completed scenarios to achieve a better score, which leads them to the correct behavior (PG-4). However, even the low-scoring choices are educational because they teach players the consequences of negative behaviors. The game provides auditory feedback for most game text. Controls can be used to pause, play or mute the audio as needed.

In parallel development, a teacher evaluation framework was built with feedback from teachers to contain this and other Mediasmarts games. With the framework, teachers can monitor student performance through game scores and detailed reports about each student's choices and actions.

### Content

Game content was designed at an appropriate reading level for our target audience in collaboration with educators experienced in designing educational material for children. We minimized text where possible by including meaningful and visually appealing graphics. The scenarios were designed to be realistic and representative of the lives of 11-13 year old children to encourage transfer of lessons in the game to real world settings (PG-5). Scenarios were designed to be light-hearted and humorous to keep children engaged. We implemented twenty-five scenarios, and structured the design such that more (up to 150) can be added in the future. Assessment was a key game requirement for our educational partner. Each scenario addresses a specific topic and educators can use the child's score and choice in the scenario to evaluate performance and determine where students are facing difficulties or have misconceptions. Additional assessment indicators on player behavior, such as time on task, can be included in the future. A comprehensive evaluation framework has been developed to allow teachers to regularly evaluate children's performance when the game is deployed in schools.

## DESIGN PROCESS

We used an iterative user-centered design process to create the game. Since the Jo Cool or Jo Fool quiz designed by MediaSmarts is still being used in schools, we used it as a starting point for the design of our new game. We began by conducting a user study of the quiz to discover areas of weaknesses and strengths. Findings from the study were discussed with MediaSmarts to identify requirements for the game, educational topics, and the target audience. Next, we created three candidate visual designs for the game and evaluated them with children. Feedback from the study was used to improve and create our final design, which was then prototyped in Adobe Illustrator and partially implemented in HTML5. We then conducted a user study to evaluate our medium fidelity prototype with children. Using feedback from the study, we refined our designs and completely implemented them in HTML5 to create a production quality game. Finally, we conducted a two-part summative user study on the high-fidelity prototype to evaluate its usability and effectiveness at meeting the learning goals. Our educational partner, MediaSmarts, was closely involved at each stage of the design process, to ensure that their requirements and goals were being satisfied.

## USER STUDY 1: EVALUATION OF THE OLD QUIZ

A formative user study was conducted with 16 children (7 girls, 9 boys) between the ages of 11 and 14 to evaluate the existing "Jo Fool or Jo Cool" quiz [31]. Participants completed a pre-test questionnaire, completed parts of the quiz, and then completed a post-test questionnaire. In addition to

this, an eyetracker tracked children's gaze while they interacted with the quiz. Questionnaires collected demographic information, pre-test/post-test knowledge of the quiz topics, and their perceptions and experience of completing the quiz. The quiz consists of twelve mock websites which users assessed to determine whether the characters Jo and Josie made the correct decision. For example, a website might collect personal information, and the user is asked whether Jo was right to provide his information. The quiz then reviews the user's choice and associated consequences. Due to time constraints, participants in our study only looked at two or three websites in the quiz. The websites were assigned to participants to ensure reasonable coverage of all scenarios.

We analyzed the results to look at three aspects of the quiz: content length, relevance of topics, and visual design[1]. We noticed that younger children were slower readers compared to the older children. Eyetracking data revealed that children read the text line-by-line or in a zig-zag pattern. In the zig-zag pattern they read some text, drifted their gaze to another object on the screen, and then returned to the text. This pattern was commonly observed in slow readers who frequently asked whether they really needed to read the text. Participants skipped reading chunks of text on websites which were text-heavy. Participants liked that the scenarios depicted real-world situations for real people and consequences of dangerous online behavior. Most participants did not like the design of the websites and the overall quiz layout. However, the eyetracking revealed that participants were drawn to Jo and Josie's faces, especially when they made eye-contact with the user. The characters got as much attention as the text, except in cases where their eyes were closed.

With regards to learnability, participants used a 5-point Likert scale (1 = nothing, 5 = a lot) to rate how much they learned from the game. Overall, participants felt they did not learn much from the game ($M$ = 3.03, $SD$ = 1.04). Similar results were observed by analyzing the pre-test and post-test knowledge questions. For 7 out of 12 scenarios, knowledge did not improve, because children already had the correct knowledge or because they retained their misconception. Overall, children liked the characters of Jo and Josie and the scenario-based approach of the quiz. However, they did not like the visuals, found the content to be outdated, and did not read large blocks of text. For our new game, we kept the main characters of Jo and Josie, a brother sister duo, and the scenario-based approach since they were positively received by users.

## USER STUDY 2: EVALUATION OF VISUAL DESIGN

We created three alternative visual designs for the game and tested them with children to determine their preference. In particular, we were interested in evaluating the age appropriateness of the main characters, overall colour scheme, and design. A user study was conducted with eight 10-12 year old children. For continuity, four returned from the previous study. Participants were shown each of the three designs in a random order and were asked to provide their opinions. We asked specific questions regarding character preference, layout, background, and colour scheme to help them articulate their opinions. We also tested the text of some of the game scenarios. Since the scenarios did not have a visual representation, we read them as a script and asked participants for their opinions on the content and choices that Jo and Josie should make. Scenarios varied from Josie getting cyberbullied in an online game to Jo posting a funny comment on an embarrassing video of a friend.

Most participants preferred the characters in either Design 1 or 3. Two participants liked Design 3 because the characters looked older and could teach them about situations they might encounter in the future. Most participants preferred the look-and-feel and colour scheme of Design 3. They liked the blurred background and thought the design looked modern. We used this feedback to revise our designs. Specifically, we combined the facial expressions of the characters in Design 1 with the bodies of Design 3, and chose the colour scheme and layout of Design 3. Figure 1 shows our final design. Participants had a strong sense of wrong and right in the scenarios. For example, in the bullying scenario they wanted to confront the bully or ask them to stop. However, this is not always the best choice as confronting bullies can worsen the aggression. These types of comments suggest that the game should include scenarios where the line between right and wrong is unclear, so children can learn about more nuanced situations. They also suggested using more visuals to describe scenarios instead of using text.

## USER STUDY 3: EVALUATION OF MEDIUM FIDELITY PROTOTYPE

This study assessed the usability of the medium fidelity prototype, the interaction flow, and the storyline before full implementation. Five scenarios from the cyberbullying day were fully implemented in HTML5, and the remaining four days and 20 scenarios were tested in PowerPoint using a wizard-of-oz approach. Other game elements such as scoring, news feed, and the review screen were also implemented. The medium-fidelity prototype was evaluated with fourteen 11-13 year old children. Participants completed a pre-test questionnaire and interview, played the game, and then completed a post-test questionnaire and interview. They were also asked to think aloud during the study (see [34] for details).

Each participant played the functional day in HTML and a second pseudo-randomly assigned day. Participants were audio recorded and an eyetracker recorded their gazes during gameplay. Results from several 5-point Likert scale questions showed that participants found the length of the content to be acceptable ($M$ = 3.71, $SD$ = 0.99), found the scenarios interesting ($M$ = 3.85, $SD$ = 1.09), enjoyed playing the game ($M$ = 4.07, $SD$ = 0.99), found the game fun ($M$ = 4.42, $SD$ = 0.64), and liked the visual design ($M$ = 4.35, $SD$ = 0.63). Returning participants liked the visual design better than the old quiz. Qualitative feedback supported these results, where a user stated "I really like how it follows the Jos around through the events of their day". Eyetracking data revealed that participants were attracted to characters' faces and other game elements, such as the score and news feed. Qualitative feedback confirmed that participants liked the scoring and news feed features. They expressed excitement after receiving a

[1]For our formative studies, we focus on results that influenced later phases of our design. More extensive results are available in [34].

high score or wanted to know how they could improve. Overall, participants liked the game; they particularly liked how the game showed current events using electronic devices and social media. They also liked the age appropriateness of the content, use of animations, and feedback.

## USER STUDY 4: EVALUATION OF FUNCTIONAL GAME

The English and French versions of the game were fully implemented using HTML5, JavaScript, and CSS. A log-in page was created to allow tracking of user data during game play. The game was designed and tested on both desktop and mobile devices. The complete game had 25 playable scenarios.

### Methodology

We conducted a two-part study to evaluate the usability and effectiveness of our fully functional game.[2] The first session took an hour, and the second session about 15 minutes. The second session took place one week after the first, and assessed whether children retained the knowledge learned in the game. Participants completed a pre-test questionnaire and a short interview. Next, they played the English version of the game on a laptop and completed a post-test questionnaire and interview. To keep the session length manageable, children played three of the five days. In the second session, children completed a questionnaire and an interview. The pre-test questionnaire included demographic questions and 15 knowledge questions (three questions per day of the game). An example knowledge question was: *When using your mobile device, how often would you fact-check information before sharing it on social media?*. Participants responded by choosing an option from *always*, *often*, *sometimes*, *rarely*, and *never*.

The post-test questionnaire collected opinions of the game and repeated the 15 knowledge questions. These questions were also repeated in the one-week questionnaire to see if children improved and retained knowledge. The interviews evaluated whether children could apply their knowledge to new situations. They were provided with five situation-based questions (one per day of the game), regardless of which days they played, with reasoning that playing part of the game may raise their awareness and critical thinking skills in related topics not explicitly covered. We asked what they would do, how it would affect their privacy and that of others. For example: *All your friends are playing a popular online game so you decide to sign-up for the game as well. When you sign-up, the game asks you to provide your full name (first and last name) and your home address, so that other players can contact you. What would you do in this situation? How might this affect your privacy? How might this affect others' privacy?* We created three sets of the questions and used a Latin square to decide which to use in the pre-test, post-test, and one-week interviews. The sets were similar in structure and evaluated the same topics, but had a different context to avoid children simply repeating their previous answers. Each interview took about 10 minutes and was audio recorded. The game was instrumented and recorded user choices, time to complete tasks, and the number of points earned. We also used an eyetracker to track gaze during gameplay. Participants were encouraged to think aloud while playing.

[2]Preliminary results were published in [28].

| Day | N | Score (/10) | Time (min:sec) |
|---|---|---|---|
| | | *M (SD)* | *M (SD)* |
| Cyberbullying | 16 | 7.38 (1.15) | 4:31 (0:54) |
| Online tracking | 15 | 6.40 (2.20) | 4:47 (0:52) |
| Privacy | 15 | 7.67 (1.95) | 5:10 (1:10) |
| Sharing Online | 13 | 9.54 (1.56) | 4:48 (0:57) |
| Authentication | 16 | 4.69 (1.96) | 5:13 (1:06) |

**Table 2:** Children's mean game score and mean time per day.

### Participants

Twenty five children (10 girls and 15 boys) participated in the study. None had participated in previous studies. Fifteen were 11, nine were 12, and one was thirteen years old. They spent an average of 1 hour and 27 minutes online per day. Participants had access to computers (96%), tablets (80%), smartphones (44%), and music players (28%). Most used social media several times a day (40%), while some used it daily (16%) or monthly (8%). Most children (92%) reported some knowledge of how to protect their privacy online and how to behave on social media, saying they learned it from school (88%), parents (76%), and friends (16%).

### Results

**Time and scores:** Table 2 shows players' mean scores and the time they took to complete each day in the game. The number of participants varies because participants only played 3 game days each. On average, they took 5 minutes to complete each day. The scores show that participants found the photo sharing day easiest. They found the days covering online tracking and fact checking information most difficult, which suggests that participants were least familiar with these topics.

**Usability:** The post-test questionnaire, included seven questions to evaluate the usability of the navigation, content, storyline, and fun of the game. One question measured the challenge aspect of the game, however we observed that children had different interpretations of challenge, making the results unreliable so we excluded it from our analysis. All questions used a 5-point Smileyometer [44]. Figure 3 shows that participants were very positive in their responses. Most were able to find and use the navigation controls easily, and found the game content easy to understand. Some did not understand certain words or could not read the text because it was too small. Most found the storyline interesting and enjoyable, because they learned new concepts (e.g., using the rumor busting website Snopes), liked the overall design and artwork, liked the characters, and found it realistic and relatable. One participant stated *I liked that the scenarios were realistic. They could mentally prepare you if you encounter them in the future, so you would know how to deal with them*. Most participants found the game fun, because it offered lots of interactions, engaged their critical thinking skills, included appealing graphics, and was relatable for their age group.

**Characters:** We asked children's opinion of the main characters, Jo and Josie, using open-ended questions. Most had positive perceptions of the characters. 52% thought that the

| Measure | Pre-test | Post-test | One-week-test |
|---|---|---|---|
| | ***M (SD)*** | ***M (SD)*** | ***M (SD)*** |
| Knowledge | 55 (4) | 60 (5) | 60 (5) |
| Behavioral Intent | 30 (4) | 35 (4) | 36 (5) |

**Table 3:** Children's digital literacy knowledge (out of 75) and behavior (out of 45) scores at three time points. We note that these scores are generally lower than expected because children did not play the entire game but answered all knowledge and behavior questions.

characters were nice, interesting, and likeable. 24% thought that the characters were realistic and relatable. One user stated *They were kind of relatable because they're around my age and if I used social media more often, I could also be having these problems, so it would be valuable to play this game and learn*. We asked children to rate the characters' likeability on a 5-point Smileyometer, with 1 being very dislikeable and 5 being very likeable. Most found the characters very likeable ($M = 4$, $SD = 0.64$). Participants were clearly engaged with the characters and had formed opinions of them. Most said they would like to be friends with Jo (40%) and Josie (52%) if they were real people. Participants wanted to be friends with the characters because they had similar interests (e.g, skateboarding, video games), thought they were nice, and smart. One user stated *Josie also seems like a nice person, and she has a lot of good friends that would be able to back her up in situations, and by extension back me up in a lot of sticky situations*. Some participants were unsure about being friends with Jo (44%) and Josie (36%) because they did not know enough about them or did not have shared interests.

### *Knowledge*

Children's digital literacy was measured using the fifteen knowledge questions and five behavior scenarios that they completed at three time points: pre-test, post-test, and after one week. We added participants' scores for each of the fifteen questions and gave them a total digital literacy knowledge score out of 75 (5 per question). Table 3 shows a summary of participants' pre-test, post-test, and one-week test knowledge scores. We conducted a one-way repeated measures ANOVA to determine whether children's digital literacy knowledge scores changed over time. Using a Greenhouse-Geisser correction, we found statistically significant differences in children's digital literacy knowledge scores over the three time points ($F(1.56, 37.35) = 11.05$, $p < 0.001$, $\eta_p^2 = .32$). Post-hoc analysis using the Bonferroni correction revealed that children's knowledge scores improved significantly from pre-test to post-test ($p < .004$) and from pre-test to one-week test ($p < .004$). No significant differences were found between post-test and one-week scores ($p < 1.00$), indicating that children had retained the knowledge they learned in the game.

### *Behavioral Intent*

Children's behavioral intent scores were derived from the interview data. The interviews were transcribed from audio recordings and the responses were organized in Excel according to the 15 interview questions (3 questions $\times$ 5 scenarios). A researcher coded each response on a 3-point scale (3 = very good, 2 = marginal, 1 = poor) for a total out of 45 points. The responses to one question could not be accurately coded, so we assigned it the middle score of 2 for each participant.

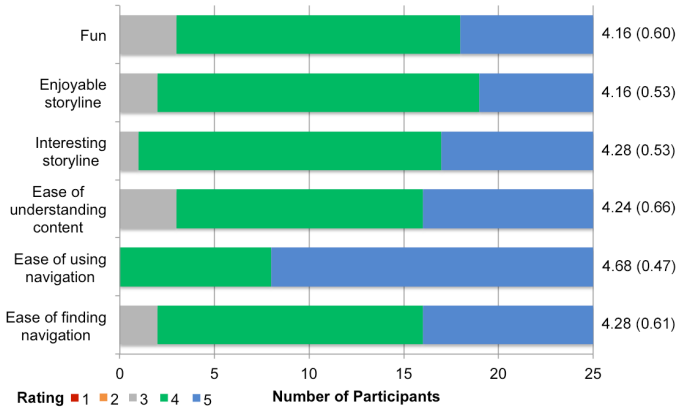


**Figure 3:** Children's usability evaluation of the game (1 = most negative, 5 = most positive)

A second researcher independently coded the responses for the first 13 participants. A Cohen's Kappa (k) test showed moderate agreement between the two researchers' analysis of the pre-test (k = 0.65, 95% CI: .6 to .7, $p < .000$), post-test (k = 0.62, 95% CI: 0.5 to 0.7, $p < .000$), and one-week-test scores (k = 0.57, 95% CI: 0.5 to 0.7, $p < .000$). In cases of disagreement, the two researchers discussed and consolidated the scores to be used in the final analysis. Since the researchers had moderate agreement, only the first researcher coded the responses for the remaining 12 participants. Table 3 shows a summary of children's digital literacy behavioral intent scores. We conducted a one-way repeated measures ANOVA on these scores to see if they improved over time. A Mauchly's Test of Sphericity found that the scores significantly improved over the three time points ($F(2, 48) = 50.13$, $p < 0.000$, $\eta_p^2 = .68$). Post-hoc analysis conducted using Bonferroni correction revealed that children's behavioral intent scores improved significantly from pre-test to post-test ($p < .001$), pre-test to one-week test ($p < .000$), and post-test to one-week test ($p < .019$); again showing that playing the game led to sustained improvements.

### *Eyetracking*

We examined fixation patterns in the videos generated by the eyetracker to see which elements of the game received attention from users and how they interacted with them. In general, elements in the game did not compete for children's attention because we used animation to sequentially present elements and guide their attention.

**Common Elements:** Common elements include the audio player, score area, and "next button". Most users noticed the audio player, but none used it to control the voice narration in the game, which was on by default. In fact, this area received the least attention, suggesting that the audio was at a good reading pace for children, and synced well with the game text. Children looked at their total score periodically, especially after making a choice in a scenario. They used the score to evaluate their performance, which suggests that it acted as a motivator. Users were able to easily locate and use the "next" button to navigate between scenes in a scenario.

**Text and Graphics:** The game contains a considerable amount of text, however, we tried to facilitate reading by

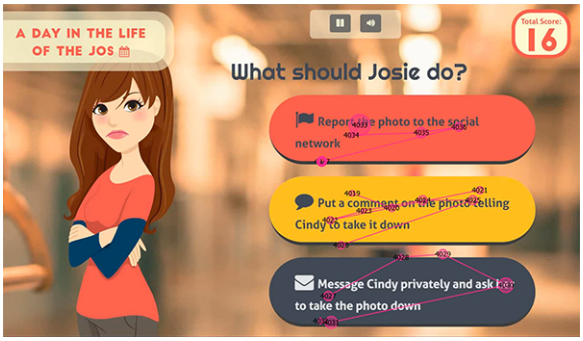


**Figure 4:** Scanpath of a child's gaze when reading choices in a scenario.

using humor, chunking text, and combining text with visuals. We used eyetracking to determine children's reading behavior, and found that they read most of the game text and news feed. In the feed, a new entry sometimes appeared before children were finished reading the previous entry. When this happened, children continued to read the previous entry and moved to the new one when they were finished. Some children read the text multiple times, especially when it was long, but most read it only once, suggesting that it was easy to comprehend and at an appropriate reading level. Many children did not read text embedded in an image. This could be because they thought it was not important, the font was too small, or the text was too long. They sometimes did not read text in the day review screen, possibly because it was too long or they were listening to the audio narrator instead. We observed that after playing two consecutive days in the game, children started to experience reading fatigue, which is when they would skip reading text in the day review screen. Children paid close attention to the list of choices presented in each scenario. They read each option multiple times, suggesting that they were considering the consequences of each option before making their choice. This was evident from their gaze patterns (Figure 4) and the time spent on the choices page. When game characters were present, children focused on their faces, particularly the eyes.

## DISCUSSION

We applied procedural rhetoric to our game, creating an environment where children can explore meaningful digital literacy scenarios and gain an understanding of the consequences of their actions. Our game shows that simple game mechanics and narrative as advocated by procedural rhetoric can effectively teach children about a complex issue such as digital literacy. The simplicity of the game allows children to focus on the persuasive message of the game instead of being distracted by complex narrative or game mechanics. Procedural rhetoric was particularly helpful because, in most cases, security and privacy cannot be adequately defined by a set of rules; most situations are nuanced and we need children to develop empathy, awareness, vigilance, and an ability to weigh the potential consequences of their actions.

The game helped children become more conscious of their decisions, even for topics that they had not yet learned, since each child answered pre/post questions relating to all topics regardless of whether they had viewed that scenario. We believe that our procedural rhetoric approach was at least in part responsible for this shift in mindfulness. The children were overall more conscious of their actions after game-play, and several families reported that the game led to family conversations about online security and privacy issues. Given these positive outcomes, we believe that procedural rhetoric is an effective approach for children's educational games addressing such nuanced subjects, at least for this age group.

### Meaningful Choices and Scenarios

The game choices and narrative allowed users to gain a more thorough understanding and be more mindful of the digital literacy issues, including privacy and security. We designed the choices such that both the "right" and "wrong" choices were interesting for children, reflecting real-life situations where the line between right and wrong is unclear. While the game nudges children towards more desirable security and privacy-conscious behaviors by offering more positive outcomes for these choices, the "wrong" choices help children understand the main message of the game by demonstrating possible negative consequences and encouraging reflection.

We spent significant effort into devising realistic, relatable situations to engage players and have them be invested in the game outcomes. For a digital literacy game, some scenarios required the main characters to engage in negative behaviors (e.g., sharing someone's photo without permission). To make these scenarios relatable, we framed them to represent situations where the characters accidentally engaged in the behavior without malicious intent. This allowed children to develop empathy for the characters, and understand how children their age could engage in these behaviors. Thus, by playing the game, children not only learned how to avoid these behaviors but also developed an understanding, empathy, and tolerance for individuals (e.g., friends) who might engage in them.

### Game Characters

Characters in our game were part of the narrative, which persuaded children's digital literacy behaviors in the game. For the game to be effective at persuading children, it was important that they had positive associations with the game characters, otherwise they would be less inclined to learn from them. To facilitate positive associations, we chose two main characters so both boys and girls could relate, and designed them to be representative of 11-13 year old children. When using them in game scenarios, we made sure that both Jo and Josie were represented equally in situations where they were the victims of negative behavior and situations where they had an opportunity to practice negative behavior. While children had an overall positive perception of the characters, some showed a same-gender preference for either Jo or Josie. Some boys expressed that they would be friends with Jo and not Josie and the girls expressed a similar preference for Josie. These preferences were due the fact that most children in our target audience have same-gender friends. We similarly tried to include diversity in ethnicity, abilities, and appearance among the secondary characters. Based on our participant reactions, we believe that characters in children's educational games should have appropriate diversity so that they are relatable by most of the target audience.

### Replayability of the Game

The game allows children to easily replay the scenarios in a completed day, so they can see the consequences of different choices. Each scenario in the game can be replayed at least three times to show different consequences. Replayablity also happens outside the game when children discuss the events in the game with their parents, friends, or teachers. This is the main goal of a persuasive game, to open the game topic for further discussion and deliberation outside of the game. We observed this happening in our summative study, when kids discussed the game with their parents immediately after finishing the session. At the second session, some parents told us that they used to events in the game to have further discussions about security and privacy with their children. These types of discussions are important as they reinforce the concepts learned in the game and can be an opportunity for parents to discuss situations not covered in the game. Children can also use the game to discuss specific situations they have experienced personally, with parents or teachers who can advise them on how to behave in the future. When used in a classroom, teachers can facilitate the discussion from the game and complement it with additional material. Having a discussion in class may also help students learn from their peers' experiences which may be different than their own experiences. Thus, the narrative aspect of persuasive games fosters discussion among the players, which is not be possible in other types of games (e.g., action games).

### Designing Security and Privacy Games

Security and privacy are key digital literacy topics. Designing educational material for these topics presents some unique challenges. First, security advice keeps changing due to the evolution of attacks and introduction of new threats. Thus, we simply cannot educate users about the correct behavior once, as in other domains such as health (e.g., brushing teeth), and need to constantly re-educate them. This requires users to unlearn certain behaviors and re-learn new behaviors, which is difficult for adults let alone children. Thus, in addition to teaching correct behaviors, security games need to develop critical thinking skills in children which they can use to deal with new types of attacks.

Privacy is a nuanced topic which does not always have a *correct* answer, so it requires users to learn and understand the consequences of different choices, some of which may not be apparent for many years. For youth, an example of this is sharing questionable pictures on social media. A potential consequence of this action is that it might affect their employability, as employers often take social media profiles into consideration during the hiring process or admission to university. Because this consequence is so far in the future, it can be difficult to persuade youth to change their current behavior. In real life, some security and privacy situations have multiple reasonable paths, while others provide choices where each choice has different benefits and risks. In these cases, the best approach is to educate users about all possible choices and consequences, and allow them to choose the best path given their personal preferences. Thus, the objective of digital literacy tools is not only behavior change, but also to create informed digital citizens equipped with critical-thinking skills in an evolving digital world.

Security and privacy advice presented in games should reflect children's reality and not an adult's perspective on how children should behave online. For instance, with regards to social media, some security experts believe that children under 13-years old should not use social media because they are under the minimum age requirement of most social media platforms [2]. However, the reality is that many children under the minimum age are regularly using these platforms. Thus, instead of advising children to not use these platforms, we should advise them on how to use them safely and avoid common pitfalls associated with their use.

### Modularity of the Game

We designed the Jos so that new scenarios can be added without significant development effort. This feature is important for digital literacy games due to the evolution of attacks and introduction of new threats. Scenarios can also be added to address topics that become important due to the culture or political climate (e.g., spotting misinformation in the era of "fake news"). Although, the game has been designed for 11-13 year old children, it can be extended to be suitable for younger children. To do this, new scenarios and graphics can be designed to address the digital literacy topics appropriate for younger children, without needing to change the *A Day in the Life Of* design of the game. Children might benefit from such a game where they are able to see Jo/Josie's digital lives evolve with them as they grow older. This might also help them develop an improved rapport with the characters.

### Evaluating Persuasive Games

To show the effectiveness of the our game we measured players' behavioral intent instead of their actual future behavior, which is difficult to measure especially in situations that teach users how to behave safely in dangerous situations. For each topic addressed in the game, we presented a fictitious scenario, and asked children how they would behave in that situation, how their behavior will affect them and others. Participants' responses to these questions were used to measure their digital literacy behavioral intent. We found that measuring behavioral intent and usability of the game together resulted in a long session which can potentially fatigue child participants. Thus, when this measure is used to evaluate the effectiveness of persuasive games with children, we recommend either evaluating the usability and behavioral intent in two sessions or reducing the number of questions in the usability questionnaire.

### Design Recommendations

Based on our experience with the Jos game, we propose five recommendations for designing children's educational games using procedural rhetoric. We suggest using these recommendations in conjunction with Ferrara's guidelines for designing persuasive games, which include defining a core message, tying the message to strategy, enabling self-directed discovery, offering meaningful choices, and keeping it real [12].

#### *R1: Game must have a strong and engaging narrative*

Mechanics (rules) are at the heart of a procedural rhetoric game [7]. However, we argue that having a strong narrative is

equally important. In fact, an effective application of procedural rhetoric must include both, and the narrative should be used to convey the message encoded in the game mechanics. In the Jos game, children liked the scenarios (narrative) and the ability to make a choice (mechanic) the most. In our user study, children played 15 scenarios and wanted to play more because they were interested in seeing what else would happen to Jo and Josie. Thus, the narrative kept the children engaged and motivated to play the game, which helped their retention of the learned material [21]. Due to this, we believe that without an engaging narrative children will be less interested in playing a persuasive game, regardless of the game mechanics, decreasing it's ability to change the intended user behavior. However, it is important to not make the narrative too complex because it will increase the cognitive load on the player and take away resources from the learning material [6].

*R2: Game narrative must be age appropriate*

Persuasive games are composed of a narrative and game mechanics, where the narrative includes context, setting, storyline, scenario, and characters. All these elements of the narrative should be designed to be age appropriate and relatable for children. We designed the Jos game so that the characters and scenarios were relatable for our target audience of 11-13 year old children. These were validated by our last user study, where one of the things children most liked in the game was that the scenarios were realistic and modeled situations they would encounter in their daily life. They also had positive associations with the game's main characters (Jo/Josie) and thought they were good characters who always tried to do the right thing, even in negative situations. They also found the characters relatable for children their age.

The realistic scenarios and characters allowed the children to learn the educational material more effectively in the game, because they could use prior experiences and knowledge to process new information and concepts from the game [30]. It also helped them apply the learned material to situations outside of the game, as shown in the post-test interviews. Children's positive perception of the main characters make them more likely to trust the advice given by these characters. To establish a positive association, the main characters of a persuasive game should model positive behaviors relevant to the simulated environment, be age appropriate and relatable [6]. For certain types of domains, designers need to find a balance between realism and age appropriateness of the simulation. This is true for cybersecurity, where some children take part in risky online behaviors which may be inappropriate to model in a simulation for all children of that age group.

*R3: Game must provide realistic choices*

While many types of realism can be applied to a game, choice is at the heart of procedural rhetoric; therefore, it is particularly important that choices within the game are realistic. The choices provided in the game must be realistic and reflect the kinds of choices that children would make in real life. If children are unable to find a relevant choice in the game, they will pick something that does not reflect their real world behavior, and this will negatively impact the effectiveness of the game. In one scenario of our game, some children wanted to choose an option that was not present in the list of choices, and they were disappointed that they could not make a choice reflective of their behavior. This scenario did not have a negative impact on our game's effectiveness, because their desired choice was positive and equivalent in points to the choice they ended up making. However, we note that this could have negatively impacted the effectiveness of the game. Since procedural rhetoric is used to model complex systems, the game should provide an adequate number of choices to children and not just provide an extreme positive and negative. We need a realistic range of options without providing an overwhelming number of choices. In our experience, this appeared to be 3-5 choices. We suggest providing more nuanced choices to reflect the types of choices available to children in real life. We chose this strategy for the Jos game, and most children were content with the number of choices provided. With respect to realism of the narrative as it relates to the choices, the main message of our game was not to disengage and stay offline. Rather, we offered options for handling tricky situations and making informed choices.

*R4: Game must provide an opportunity for reflection*

The game should provide opportunities for children to reflect on the consequences of their choices. Reflection allows children to realize what they did wrong and how they can improve in the subsequent parts of the game. In the Jos game, we offered two opportunities for reflection: immediately after viewing the consequences of a choice and after completing a whole day (5 scenarios). To minimize disruptions, the short message at the end of a scenario only tells the player how their choice affected Jo or Josie. The complete summary provided at the end of a day shows them their choice, consequences, the correct choice, and how they can improve in the future. This kind of reflection leads to a better understanding of the educational material than simply being told that a choice was incorrect [10]. It also helps with the retention and knowledge transfer of the material learned form the game, as shown in the post-test interviews and questionnaires [21]. However, too many opportunities to reflect can be disruptive and annoying for children because it takes away their attention from the primary task, which is to play the game. Thus, designers should provide a balance between offering opportunities to reflect and not disrupting the player's flow.

## CONCLUSION AND FUTURE WORK

With the growth of children's technology use, it has become increasingly important to improve their digital literacy skills. We used procedural rhetoric to design and develop a digital literacy game for 11-13 year old children, meant for classroom use. Our summative study showed that the game was effective at improving children's digital literacy knowledge and behavioral intent immediately after playing the game and one week later. These results will give confidence to teachers interested in using the game in their classrooms. Based on our experience of designing the game, we proposed five recommendations for designing persuasive educational games for children, which can help future designers creating such games. We are currently evaluating the game with teachers to explore how it can be incorporated into classrooms. The results from this study will be used improve the game, and it will be then be deployed to schools across Canada.

## SELECTION AND PARTICIPATION OF CHILDREN

All our user studies were reviewed and cleared by our institutional review board. Participants were recruited through social media parenting groups and by distributing flyers at after-school programs in the Ottawa area. Sessions ranged from 45-90 minutes and were audio-recorded. At the start of the session, a parent provided written consent for their child's participation and the child provided verbal consent. Each participant received a $20 gift certificate or cash. Parents were reimbursed for parking costs when applicable. Sessions took place in our research lab or other quiet, mutually convenient locations (e.g., public library). When sessions took place outside the lab, we chose locations with minimal distractions. We also ensured that other children or adults were not nearby, to avoid accidentally audio recording them.


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