

Teacher Views on Storytelling-based Cybersecurity Education with Social Robots

Yan-Ming Chiou
Department of Computer and
Information Sciences, University of
Delaware
steveice@udel.edu

Tia N Barnes
School of Education, University of
Delaware
tbarnes@udel.edu

Shameeka M Jelenewicz
College of Human Development and
Family Sciences, University of
Delaware
sjelenew@udel.edu

Chrystalla Mouza
School of Education, University of
Delaware
cmouza@udel.edu

Chien-Chung Shen
Department of Computer and
Information Sciences, University of
Delaware
cshen@udel.edu

ABSTRACT

With children spending more time online, personal data are stored on their devices making them susceptible to online risks. Exposing students to cybersecurity education at an early age is critical for raising awareness and knowledge. Yet access to cybersecurity education curricular materials that are engaging for young students is limited. In this work, we present interactive cybersecurity stories for students in grades 3-5 delivered through a commercial social robot. Through focus groups and interviews we subsequently investigated teachers' views on using a social robot for cybersecurity education, interest in incorporating social robots in the classroom, and perceptions of the ways in which social robots can impact teaching practice and student learning. Findings indicated that teachers found the social robot engaging and expressed interest in using it in their classroom despite some concerns. Findings have implications for the design and implementation of cybersecurity curricula delivered through emerging technologies.

CCS CONCEPTS

• **Human-centered computing**; • **Empirical studies in HCI**; • **Social and professional topics**; • **Professional topics**; • **Computer education**; • **K-12 education**; • **Applied computing**; • **Collaborative learning**;

KEYWORDS

Social robots, K-12 education, STEM, Cybersecurity education, interest development, Collaborative learning

ACM Reference Format:

Yan-Ming Chiou, Tia N Barnes, Shameeka M Jelenewicz, Chrystalla Mouza, and Chien-Chung Shen. 2021. Teacher Views on Storytelling-based Cybersecurity Education with Social Robots. In *Interaction Design and Children (IDC '21)*, June 24–30, 2021, Athens, Greece.

Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for third-party components of this work must be honored. For all other uses, contact the owner/author(s).

IDC '21, June 24–30, 2021, Athens, Greece

© 2021 Copyright held by the owner/author(s).

ACM ISBN 978-1-4503-8452-0/21/06.

<https://doi.org/10.1145/3459990.3465199>

'21), June 24–30, 2021, Athens, Greece. ACM, New York, NY, USA, 5 pages.
<https://doi.org/10.1145/3459990.3465199>

1 INTRODUCTION

As children spend more time online, personal data are stored on their devices making them susceptible to online risks. Educating children about cybersecurity as they increasingly use the internet is one way to address the threats that lurk online, safeguard against malicious software or websites, and protect their personal information. However, only recently computer science standards have started devoting enough attention to cybersecurity education. A recent summit organized by the Computer Science Teachers Association (CSTA) on emerging concepts for computing education recognized the importance of cybersecurity and provided guidance for teachers on how to integrate cybersecurity concepts in education [1, 2].

One way to engage students with cybersecurity education is through emerging technologies, such as social robots. Social robots are internet-connected smart devices that can be integrated into people's everyday lives and have built-in intelligent interactive voice assistants like Siri, Google, and Alexa, which are popular with children. Unlike voice assistants that lack human-robot interaction interfaces, however, social robots encompass both verbal and non-verbal capabilities as well as mobility throughout the physical environment [3, 4]. Further, they are often equipped with human like features (e.g., eyes, sounds) making them more appealing to children [5]. This combination of humanoid features, physical presence, and ability to actively involve users is considered more socially appropriate and meaningful when working with children [3, 6]. As such, social robots can be successfully used to offer engaging and personalized learning experiences to children that are more likely to sustain child-robot interactions [3]. In this work, we describe one approach to using a commercial social robot, called Zenbo, to help students learn about critical cybersecurity concepts. First, we describe a participatory design approach that engaged K-8 teachers in developing interactive stories for Zenbo that addressed cybersecurity concepts. Subsequently, we examined teacher participants' perceptions regarding Zenbo as well as their views on opportunities and anticipated challenges in using Zenbo in the classroom for cybersecurity education.

2 RELATED WORK

2.1 Recent Cybersecurity Education Programs in K-12

In recent years, several programs have emerged to teach cybersecurity concepts in more engaging and stimulating ways. Most programs utilize game-based designs to raise interest and support collaborative learning as students play and learn together [11–14]. Tablas et al. [11] created a group-based card game called *Crypto Go* to teach the mathematical concept behind cryptography, which is a fundamental concept of cybersecurity. In the *Crypto Go* card game, players take turns to pick a card, and the goal is to collect certain special winning sets of cards that represent solid cryptographic constructions. Wen et al. [13] introduced an anti-phishing online game called *What.Hack* to simulate a real-world phishing scenario. In this game, the player's mission is to use the given toolset, e.g., document, and ask the advisor to differentiate the real email from the phishing email. Finally, Veneruso et al. [14] used Virtual Reality (VR) to create a highly immersive VR cybersecurity role-playing game, called *CyberVR*, to teach six essential concepts in cyberspace. In *CyberVR*, the player acts as an administrator to secure the IT system. To the best of our knowledge, no studies exist that utilize social robots to engage students with cybersecurity content.

2.2 Using Social Robots in K-12

Social robots have already been used and investigated in both home and classroom setting to examine their potential to support cognitive and affective outcomes such as motivation, attention, and interest development in various academic areas and tasks [3, 7–10]. In most studies, social robots were utilized for short, well-defined lessons with little adaptation [10]. The role of the robot varied but most frequently they served as tutor (or teacher) or peer. Michaelis et al. [7] designed a robot named *Minnie* to serve as an in-home learning peer for children in reading. The robot was used to examine views about reading, potential uses of *Minnie* in reading, and how children perceived reading with *Minnie*. Their work indicated that *Minnie* can act as a learning companion for children, which may help promote the development of both reading interest and ability to cultivate their social behavior. In a classroom setting, Vogt et al. conducted a large-scale study [9], with 190 students, which investigated the use of a social robot as tutor, helping children learn English vocabulary as a foreign language. Vogt et al. examined the effectiveness of the social robot, the added benefit of gestures on word learning and retention, and the effect of using a robot tutor accompanied by a tablet versus learning from a tablet alone. Results showed no difference in learning performance between digital tablets and social robots and no beneficial effect of robot gestures. In a meta-analysis of literature Belpaeme et al. [10] found that social robots are effective at increasing cognitive and affective outcomes comparable to those of human tutoring on restricted tasks.

2.3 Teacher's Views of Social Robots in the Classroom

Teachers play an essential role in the classroom ultimately deciding if and how emerging technologies are used [15]. As a result, teachers need to be actively involved in the design of new technologies and

curricula to improve social validity. Few studies so far examined teachers' view and opinions related to the use of social robots in the classroom [5, 15]. Van Ewijk et al. studied the moral values related to educational robots from the teachers' perspective through focus group sessions with 18 teachers in the Netherlands [5]. In their study, the teachers provided lots of positive feedback about how social robots can bring cooperation to their class but voiced some concerns about privacy and budget issues. Similarly, Ahmad et al. [16] interviewed high school language teachers on their opinions about social robots' role in the classroom and their expectation of what robots can do to assist them. The teachers suggested the robot should be able to understand children's emotions, offer personalized material for the individual student, and allow teachers to add their material to the robot to fit the need for each course. Similar to the work of van Ewijk et al.'s [5], Serholt et al. [15] interviewed eight teachers in Europe about their opinions of bringing social robots as a tutor in their classroom. They further investigated the disruption, novelty, and other functionality that social robots raised in the classroom setting. These studies provide important insights related to teachers' views of social robots, but none of them focuses explicitly on issues around cybersecurity education, a relatively new area addressed in computing standards and curricula in K-12 settings.

3 METHODS

Introducing social robots in the school curriculum necessitates the use of tailor-made materials [10]. For this reason, we engaged 5 teachers in co-designing interactive cybersecurity stories delivered on Zenbo. We conducted two focus group sessions with all 5 teachers to solicit their input on the stories. Sessions lasted 90 minutes each and took place within 2 months of one another. Following the focus groups, we conducted individual interviews with teachers to learn more about their perspectives on having Zenbo in the classroom to deliver cybersecurity lessons.

3.1 Participants

All 5 participants provided active consent to participate in this study and received a stipend for their time. The 5 teachers, taught technology, science, STEM, and/or social studies for children in grades K-8. They were selected because of their prior involvement with computer science initiatives, experience with curriculum development in computer science, and interest in integrating new technologies in their classrooms.

3.2 Procedure

During the first focus group meeting, the research team gathered teachers' perspectives on student current cybersecurity education needs. Teachers noted that cybersecurity is a topic that parents are relatively uninformed about and voiced concerns about young children having access to devices with internet access, including phones and gaming systems, without parental supervision. Specifically, teachers were concerned that parents are not aware of their children's internet behaviors and potential online dangers. Similarly, teachers expressed concerns about students' online safety, particularly talking with strangers online. Although teachers noted



Figure 1: (a) Little Red Riding Hood: (b): Captain Cyber

that students may know the rules, they felt that they may not always apply them when the situation presents itself.

After eliciting teachers' perspectives, we presented Zenbo and provided a short demonstration of Zenbo using a pilot story developed by the research team. This story, adapted from the well-known fairytale Little Red Riding Hood, embeds lessons concerning *password safety* (Figure 1a). Throughout the story opportunities are provided for students to respond to questions on the cybersecurity topic of password safety. We asked for teachers' initial reactions to the story and their thoughts about potential opportunities and challenges with using a social robot in the classroom. Following this discussion, we presented a draft of a second cybersecurity story and elicited feedback on the story content and potential changes to the format of presenting the stories. This story, which was created by our research team, features a superhero called Captain Cyber who lives in cyberspace and protects students as they use the internet by teaching them about cybersecurity (Figure 1b). In this story, Louisa and James (the main characters) are faced with a phishing site while trying to play a new online game together. The two friends are then pulled into the video game and meet their long-time hero, Captain Cyber, who teaches the friends about *phishing* sites, what to do to identify a phishing site, and encourages the friends to ask an adult for help with navigating these sites. Similar to the Little Red Riding Hood story, students have opportunities to respond to questions related to the cybersecurity topic that is being explored.

Participating teachers noted that they liked the diversity of the characters represented in the story, the length of the story, and the story graphics. Suggestions for improvement included changing terms like "search engine" to more commonly used terms, character expansion to further engage students, and the creation of lesson plans to support educators in teaching cybersecurity lessons. At the second focus group meeting, we presented the updated story along with two additional stories for feedback. These two focus groups provided adequate opportunities for teachers to provide suggestions and feedback on the development of cybersecurity stories and served as opportunities to familiarize teachers with Zenbo and its potential in a classroom context.

3.3 Teacher Interviews

To gain a better understanding of teachers' perspectives on the use of Zenbo to deliver cybersecurity content to students in the classroom, we conducted individual interviews. Interviews occurred via phone and lasted 30 minutes. Interview topics included: (a) initial impressions of Zenbo, (b) interest in incorporating Zenbo in the classroom, and (c) perceptions of how Zenbo could impact teacher practice and student learning. All interviews were audio-recorded and later transcribed by a professional transcription service. Transcripts were then entered into Dedoose and examined using thematic analysis. A coding directory was created using the interview questions. Excerpts were identified for thematic areas to highlight the frequency of how often a single theme emerged.

4 RESULTS

4.1 Teachers' Impressions of Zenbo

Findings indicated that all teachers expressed positive responses towards Zenbo and thought that their students would enjoy the robot. As one teacher noted: "The physical shape and the face, the facial expressions in particular, made Zenbo very relatable for the kids," while another teacher responded "I liked it. I think it's got a lot of potential. I think kids will open up to that robot more than an adult probably." When asked about their interest incorporating Zenbo into their classroom, those participants already teaching some aspect of cybersecurity responded positively. One teacher explained: "I think the two stories we saw were more about digital citizenship and we focus a lot on that in K-5 in the public schools. So definitely that would be a huge tool. It was interactive. The kids could answer questions. That kind of thing would be a huge proponent in the classroom." Similarly, another participant noted: "I think the storytelling aspect can be very beneficial, and the lessons the kids get from the stories. I think they're going to really like it because there's a newness and novelty to it".

4.2 Prospective Uses of Zenbo in the Classroom

Participants considered using Zenbo in multiple ways, including for mini lessons, as a stand-alone activity, for small group work, and as another learning tool. One participant explained: "It could be

used as a small center. ...and it will just become another tool in the classroom. I think just the whole look of it, I think, is enticing for children. I think there's a lot of potential behind the robot." Similarly, another teacher noted: "I think initially, I would use it with all of the students, just to see. But I would focus on observing at that time and kind of making sure and kind of watching their engagement. I have two classes of students who have Individualized Education Plans [IEP], and I definitely think they would love it. Especially because it could reiterate some of the information in another manner, or it could be used as like a review tool if they're still not understanding it, they could go and kind of work with it."

4.3 Potential Benefits of Zenbo for Students

When asked about the potential benefits of Zenbo for their students, participants thought that they would become more interested and engaged in the subject matter. One participant explained: "They're learning about what to do and what not to do when they are online through fairytale characters. So they're making connections. Then you can take that back to the classroom and make connections between the different stories. I think it opens up a whole new world." Similarly, another teacher noted: "I think using the robot with the cybersecurity was a way to make it a little more novel and possibly more pertinent to students, which I think is important."

4.4 Potential Challenges for Using Zenbo

Despite positive responses, participants also identified challenges associated with the use of Zenbo. One concern was the cost of Zenbo in relation to its narrow scope of use. One participant explained: "In a public-school setting, I think the cost is a huge factor to get robots this size and complexity into the classroom." Other participants expressed concerns that Zenbo may initially be a distraction in the classroom, as one participant explained: "I think initially there would be a novelty that would make it a distraction." Technical and logistical issues around space was another concern raised by teachers, as Zenbo moves around a lot. One participant further explained: "So one of the challenges, I think is just typical maintenance of... His roller ball piece on the bottom would have to be taken apart and cleaned, and the charging is going to be a problem." Finally, when asked what supports they would need to implement Zenbo in the classroom, participants expressed the need for training on how to operate, maintain and troubleshoot Zenbo, in-class coaching, and opportunities to meet and discuss lessons learned with other teachers.

5 CONCLUSION

Teachers play a critical role in selecting and implementing new technologies in their classrooms [18]. Therefore, soliciting teachers' views on technology-enhanced curricular materials is essential. Similar to results from other studies [11, 17], findings from this work indicated that teachers had positive views of and interest in incorporating a social robot in their classroom to teach cybersecurity. Participants envisioned using Zenbo for short lessons, standalone activities (i.e., as a tutor), or in small groups. Participants noted that using Zenbo into their classrooms could have positive impacts on their practice, challenging them to present information in new

ways. More participants thought that their students would benefit from Zenbo, by becoming more interested and engaged with cybersecurity content. As with the introduction of any new technology, participants expressed concerns including technical challenges, cost, and potential distractions given the novelty of social robots in the classrooms. Nonetheless, participating teachers thought that use of interactive storytelling on a social robot presents an exciting and novel approach to engaging students with content that is essential in the digital era. We are currently working with teachers to implement the cybersecurity stories in their classroom and examine student learning of cybersecurity concepts as well as perceptions around using a social robot to learn about cybersecurity.

ACKNOWLEDGMENTS

This work was supported by the National Science Foundation under grant: NSF DSG-1821794.

REFERENCES

- [1] CSTA (2020). A Look at The Future of CS Summit. [Online]. Available: <https://www.csteachers.org/Stories/a-look-at-the-future-of-cs-summit>
- [2] CSTA (2021). Guidance for Schools of Education. [Online]. Available: <https://www.csteachers.org/Page/guidance-for-schools-of-education>
- [3] Cagiltay, B., Ho, H. R., Michaelis, J. E., & Mutlu, B. (2020). Investigating family perceptions and design preferences for an in-home robot. *Proceedings of the Interaction Design and Children Conference, IDC 2020*, 229–242. <https://doi.org/10.1145/3392063.3394411>
- [4] Syrdal, D.S., Dautenhahn, K., Koay, K.L., Walters, M.L., & Ho, W.C. (2013). Sharing spaces, sharing lives—the impact of robot mobility on user perception of a home companion robot. In *International conference on social robotics*. Springer, 321–330.
- [5] Van Ewijk, G., Smakman, M., & Konijn, E. A. (2020). Teachers' perspectives on social robots in education: An exploratory case study. *Proceedings of the Interaction Design and Children Conference, IDC 2020*, 273–280. <https://doi.org/10.1145/3392063.3394397>
- [6] Breazeal, C., Dautenhahn, K., & Kanda, T. (2016). *Social robotics*. In *Springer handbook of robotics*. Springer, 1935–1972.
- [7] Michaelis, J. E., & Mutlu, B. (2017). Someone to Read with: Design of and Experiences with an In-Home Learning Companion Robot for Reading. *CHI*, 2017, 301–312. <https://doi.org/10.1145/3025453.3025499>
- [8] Michaelis, J. E., & Mutlu, B. (2019). Supporting interest in science learning with a social robot. *Proceedings of the 18th ACM International Conference on Interaction Design and Children, IDC 2019*, 71–82. <https://doi.org/10.1145/3311927.3323154>
- [9] Vogt, P., Van Den Berghe, R., De Haas, M., Hoffman, L., Kanero, J., Mamus, E., Montanier, J. M., Oranç, C., Oudgenoeg-Paz, O., Garcia, D. H., Papadopoulos, F., Schodde, T., Verhagen, J., Wallbridge, C. D., Willemsen, B., De Wit, J., Belpaeme, T., Gökşun, T., Kopp, S., . . . Pandey, A. K. (2019). Second language tutoring using social robots: A large-scale study. *ACM/IEEE International Conference on Human-Robot Interaction*, 2019-March, 497–505. <https://doi.org/10.1109/HRI.2019.8673077>
- [10] Belpaeme, T., Kennedy, J., Ramachandran, A., Scassellati, B., Tanaka, F. (2018). Social robots for education: A review. *Science Robotics*, 3(21), 1–9.
- [11] González-Tablas, A. I., González Vasco, M. I., Cascos, I., & Palomino, Á. P. (2020). Shuffle, cut, and learn: Crypto go, a card game for teaching cryptography. *Mathematics*, 8(11), 1–13. <https://doi.org/10.3390/math8111993>
- [12] Karagiannis, S., & Magkos, E. (2021). *Engaging students in basic cybersecurity concepts Using digital game-based learning: Computer games as virtual learning environments*. Springer International Publishing. https://doi.org/10.1007/978-3-030-41196-1_4
- [13] Wen, Z. A., Lin, Z., Chen, R., & Andersen, E. (2019). WhatHack: Engaging anti-phishing training through a role-playing phishing simulation game. *Conference on Human Factors in Computing Systems - Proceedings*, 1–12. <https://doi.org/10.1145/3290605.3300338>
- [14] Veneruso, S. V., Ferro, L. S., Marrella, A., Mecella, M., & Catarci, T. (2020). CyberVR: An interactive learning experience in virtual reality for cybersecurity related issues. *ACM International Conference Proceeding Series*. <https://doi.org/10.1145/3399715.3399860>
- [15] Serholt, S., Barendregt, W., Leite, I., Hastie, H., Jones, A., Paiva, A., Vasalou, A., & Castellano, G. (2014). Teachers' views on the use of empathic robotic tutors in the classroom. *IEEE RO-MAN 2014 - 23rd IEEE International Symposium on Robot and Human Interactive Communication: Human-Robot Co-Existence: Adaptive*

- Interfaces and Systems for Daily Life, Therapy, Assistance and Socially Engaging Interactions, 955–960. <https://doi.org/10.1109/ROMAN.2014.6926376>
- [16] Ahmad, M. I., Mubin, O., & Orlando, J. (2016). Understanding behaviours and roles for social and adaptive robots in education: Teacher's perspective. HAI 2016 - Proceedings of the 4th International Conference on Human Agent Interaction, 297–304. <https://doi.org/10.1145/2974804.2974829>
- [17] Tanaka, F. & Matsuzoe, S. (2012). Children teach a care-receiving robot to promote their learning: Field experiments in a classroom for vocabulary learning. *Journal of Human-Robot Interaction* 1(1). 78–95.
- [18] U.S. Department of Education (2017). Reimagining the role of technology in education: 2017 National Education Technology Plan update. [online] <https://tech.ed.gov/files/2017/01/NETP17.pdf>