Knowledge of Cookies and Personalized Ads among Lower Secondary Students: Effects of a Simple Treatment

Cyril Brom[1[0000−0001−5945−0514]], Anna Yaghobová[1[0000−0002−2102−7515]], Anna Drobná[1,2[0000−0003−2714−9529]] , Daniel Šťastný[1[0009-0006-5085-2975]] and Marek Urban[3[0000−0003−2772−1388]]

[1] Faculty of Mathematics and Physics, Charles University, Prague, Czechia
[2] Faculty of Education, Charles University, Prague, Czechia
[3] Institute of Psychology, The Czech Academy of Sciences

Abstract. Little is known about lower secondary school students' understanding of cookies and their awareness of personalized advertising, and even less is known about how much this knowledge can be improved. This experimental study addresses this gap with Grade 6 (N = 44) and Grade 8 (N = 35) students. We assessed their knowledge through interviews and provided a brief, one-on-one intervention to half the participants. A follow-up interview five months later evaluated the long-term impact. Initial understanding of students was mixed, with some inaccurately believing cookies protect against online threats. Eighth-graders had better knowledge than sixth graders. The experimental group exhibited strong gain in understanding cookies ($\eta^2_p = 0.16$), but not personalized ads. This study suggests that children often have an experience-based initial understanding of digital concepts, but a simple intervention can enhance it.

Keywords: Computer science, Education, Lower secondary school, Cookies, Personalized advertisement, Conceptions, Learning.

1 Introduction

Children develop initial conceptions, also called pre-conceptions, about the world around them, including digital technologies. Understanding these pre-conceptions is crucial before developing new educational materials on respective educational targets [2]. Recent studies have mapped various child pre-conceptions about digital technologies (e.g., [1–6]), indicating an intuitive and fragmented understanding often rooted in everyday experience. Conceptual understanding of "invisible" principles behind observable aspects of these technologies is rare, even among adolescents (e.g., [1]). Additionally, evidence-based materials promoting such understanding are lacking.

Cookies are a cornerstone concept in the networking and cybersecurity strands of new K-9 computing curricula (e.g., [7]), but children's understanding of cookies and how to promote it remains underexplored. Hug [3] only briefly mentioned that

schoolchildren may have incomplete knowledge about them, a concern that also applies to adolescents aged 16–18 [9].

Hence, this study examines understanding of cookies and personalized ads (a vivid example of cookie usage) among Grades 6 and 8 students. We chose this age group because most adolescents already have long experience with digital devices [8], likely having encountered cookies and ads while browsing the web and, as constructivists frameworks imply (e.g., [2]), they should be aware of, at least, cookies' existence. However, awareness does not necessarily imply understanding. Hence, we explore whether and how much we can boost children's comprehension of these concepts.

2 Method

This study was part of a larger mixed-methods project with children involving interviews about internet principles, including cookies and personalized ads. Half received an online one-on-one tutoring session on these topics, followed by another interview five months later. Here, we present only findings about cookies and personalized ads.

Participants included 44 sixth-graders (age ~12y, 19 girls) and 35 eighth-graders (age ~14y, 15 girls) with limited prior exposure to computer science topics in school. They were recruited from various regions of Czechia via Facebook and a teacher network, and compensated with a table games worth ~50 EUR. They were randomly assigned to experimental ($n_{Gr.6/8}$ = 26/17) and control groups ($n_{Gr.6/8}$ = 24/20).

Each child participated in three 45–60-minute online sessions via Zoom: an initial interview (April–June 2022), a week-later tutoring session (experimental) or unrelated, no-instruction activities (control), and a final interview (autumn 2022). Pre- and post-interviews were semi-structured, with set questions and follow-ups based on responses. Key interview questions relevant in this paper focused on recognition and understanding of cookies and personalized ads (e.g., *Have you even heard the word 'cookie'? What does it mean to you?* etc.).

The teaching session (experimental group only) covered internet principles, including a 5–10-minute segment on personalized ads and cookies, using graphics, explanations, discussions, and activities. Key points from this segment included information we deemed relevant for and understandable by adolescents that: a) ads do not appear randomly on devices, but their content depends on our internet activities; b) what we do on the internet is stored on servers (the concept of servers was also explained); c) cookies are files allowing servers to collect information about our online behavior; d) cookies are associated with both benefits and risks (including examples of each).

Pre- and post-interviews were transcribed and analyzed using inductive (bottom-up) thematic analysis in Atlas.ti 22 by four coders and an auditor.

3 Results

Codes. The thorough inductive analysis yielded not more than three codes on cookies: 1) *awareness* without deeper understanding; 2) *partial or correct* understanding; and 3) a misconception that *cookies serve as protection*. Examples include:

1. Awareness without understanding: “You have to confirm it on the internet, that you agree with it.” (Grade 6)
2. Partial or correct understanding: “[Cookies] are small documents that save information eeh about you basically and help … show relevant ads.” (Grade 8)
3. Misconception about protection: “[Cookies] are protection against hackers [and viruses]. … it appears on a webpage when opening it. And there is an option to agree with all the protections by cookies…” (Grade 6)

Regarding personalized ads, participants either were or were not aware of them; more nuanced pre-conceptions were not found.

Pre-conceptions. In the initial interview, 22 (50%) sixth-graders were aware of cookies, 14 (32%) had a partially correct or correct understanding, and 8 (18%) never noticed cookies. Almost all eighth-graders were either aware of cookies (n = 15, 43%) or had a partially correct or correct understanding (n = 19, 54%). Better knowledge of cookies was strongly associated with awareness of personalized ads (r_s = .49, p < .001). The misconception that cookies serve as protection was noted seven times among sixth-graders and only once among eighth-graders. Additionally, 18 (41%) sixth-graders were aware of personalized ads, compared to 30 (86%) eighth-graders.

Learning. For pre-post analysis on cookies, 2 points were assigned for correct understanding, 1 point for awareness, and 0 points for neither. The intervention significantly improved knowledge about cookies (F(1, 75) = 14.73, p < .001, η^2_p =.16) for both age cohorts (F(1, 75) = 0.11, p = .739, η^2_p = .00) (Figure 1). Knowledge of personalized ads improved between pre-test and post-test (F(1, 83) = 11.74, p < .001, η^2_p = .12), but the change was similar in both experimental and control groups (F(1, 75) = 0.04, p = 0.835, η^2_p = .00). Post-learning, 17 (65%) sixth-graders from the experimental and 14 (58%) from the control condition were aware of personalized ads, whereas 17 (100%) eighth-graders from the experimental and 18 (90%) from the control condition were aware.

4 Discussion and Conclusion

We demonstrated that some sixth-graders were unaware of cookies or misunderstood their purpose, despite encountering frequent prompts to accept cookies on their personal devices. Eighth-graders generally had better, but still limited, knowledge (despite years of exposure). Older students also showed greater awareness of personalized ads. Altogether, exposure increases awareness, but not necessarily understanding. This corroborates previous pre-conception studies (e.g., [1–6]).

A brief educational intervention significantly improved students’ understanding of cookies, with effects lasting nearly six months. This suggests that enhancing conceptual knowledge of digital world elements can be achieved in schools with relatively small effort, particularly for understanding cookies. However, the intervention did not improve knowledge of personalized ads compared to the control group.

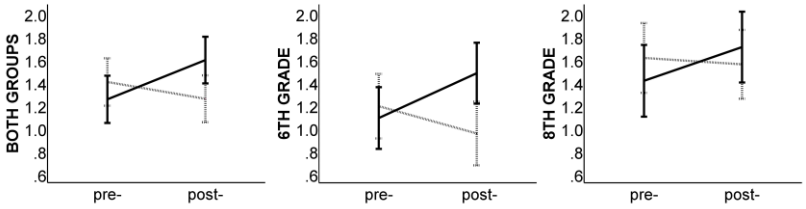

Fig. 1. Points for comprehension of cookies by pre- and post-test and experimental (full line) vs. control group (dashed line). Left: both age cohorts. Middle: Grade 6. Right: Grade 8. Scale 0 – 2.

Despite a small sample size and the tutoring nature of the intervention, the study's experimental design is a key strength. Future research should explore effects of teaching sessions about other non-programming computer science concepts, as they complement computational thinking strands of new computing curricula.

Acknowledgments. Main funding: GAČR 22-20771S. AD: Student grant GAUK 484722. AY: Student grant GAUK 360322. MU: RVO 68081740.

References

1. Brom, C., Yaghobová, A., Drobná, A., Urban, M.: 'The internet is in the satellites!': A systematic review of 3–15-year-olds' conceptions about the internet. Education and Information Technologies **28**(11), 1–30 (2023)
2. Diethelm, I., Hubwieser, P., Klaus, R.: Students, teachers and phenomena: Educational reconstruction for computer science education. In: *Proceedings of the 12th Koli Calling International Conference on Computing Education Research*. ACM, 164-17. (2012)
3. Hug, A.: "I've got nothing to hide!" survey on data privacy competence with German schoolchildren. In: *Proceedings of the 13th Workshop in Primary and Secondary Computing Education*. ACM (2018)
4. Livingstone, S., Stoilova, M., Nandagiri, R.: Children's data and privacy online: growing up in a digital age: an evidence review. London School of Economics and Political Science, Department of Media and Communications, London, UK. (2019)
5. Mertala, P., Fagerlund, J., Calderon, O.: Finnish 5th and 6th grade students' pre-instructional conceptions of artificial intelligence (AI) and their implications for AI literacy education. Computers and Education: Artificial Intelligence **3**, 100095 (2022)
6. Rücker, M. T., Pinkwart, N.: Review and discussion of children's conceptions of computers. Journal of Science Education and Technology **25**, 274-283 (2016)
7. Computer Science Teachers Association: CSTA K-12 Computer Science Standards, Revised 2017. Retrieved from https://csteachers.org/k12standards/ (acc. 2024-06-13) (2017)
8. Šmahel, D., Macháčková, H., Mascheroni, G., et al.: EU Kids Online 2020: Survey results from 19 countries. EU Kids Online. http://hdl.handle.net/20.500.12162/529 (2020)
9. Zarouali, B., Ponnet, K., Walrave, M., Poels, K.: "Do you like cookies?" Adolescents' skeptical processing of retargeted Facebook-ads and the moderating role of privacy concern and a textual debriefing. Computers in Human Behavior **69**, 157-165 (2017)