Toward the Development of HCI Pedagogical Content Knowledge

Alannah Oleson
University of Washington
Seattle, WA, USA
olesona@uw.edu

Amy J. Ko
University of Washington
Seattle, WA, USA
ajko@uw.edu

CHI'20,, April 25–30, 2020, Honolulu, HI, USA
ACM 978-1-4503-6819-3/20/04.
https://doi.org/10.1145/3334480.XXXXXXX

Abstract

The number of students enrolled in human-computer interaction (HCI) courses is continually increasing. In a recent set of qualitative studies, we identified a set of learning difficulties which may arise when computing students try to learn HCI design concepts, contributing a foundation for developing a body of HCI pedagogical content knowledge (PCK). However, our investigation extended only to the identification of these learning difficulties, not so far as strategies educators might use to mitigate these risks to learning, nor to how these difficulties might manifest differently across different educational contexts. Proposing the unsolved challenge of *developing a body of HCI PCK*, we hope to leverage the extensive expertise and diverse perspectives of the EduCHI community to tackle the next steps of PCK development, in order to promote more effective and equitable HCI education.

Author Keywords

HCI education; interface design education; learning difficulties; pedagogical content knowledge

CCS Concepts

•Social and professional topics → **Computing education; •Human-centered computing** → *Human computer interaction (HCI);*

Introduction & Background

As the number of students pursuing computer science degrees increases, more and more people are taking classes to learn human-computer interaction (HCI) principles. However, despite a growing body of research to support teaching computing principles, there remain many open questions surrounding the learning and teaching of HCI. Improving HCI education is one of the most effective ways to improve HCI itself [25], since the way that students initially learn to design software impacts the design considerations they make in their future projects [26]. Numerous prior works have found that teaching software design skills is a difficult proposition (c.f. [6, 13, 28]). Educators often struggle to engage students [11, 17, 22], to override persistent perceptions that designerly aspects of HCI are "inessential" [3], "easy," or "commonsense" [5], and to accurately assess students' design work [2, 24, 30]. Additionally, much of the research that exists in this space is limited to educators' reflections on their own particular courses [16], so students may face learning difficulties that educators do not necessarily perceive.

Student Learning Difficulties in HCI Education

One lens of analysis we have found useful to gaining insight into HCI education is that of *student learning difficulties* in HCI contexts. In a recently-concluded investigation to appear in this year's CHI proceedings, we explored what computing students struggled with when learning HCI design skills through a series of qualitative studies [21]. We scoped our investigation to software interface design learning, surveying and interviewing more than 130 students at two universities who were enrolled in introductory software interface design classes as well as 35 self-identified HCI educators from multiple different countries and institutions. Triangulating our results with prior work, we collected a set of 18 student learning difficulties that may arise in HCI education contexts. The full set of learning difficulties and a short description of each can be found in Table 1.

Tag	Student Learning Difficulty
WHAT	What is design?
WHY	Why do we do this design activity in this way?
HOW	How do I perform this design method?
INFO	How/where do I find a design resource?
ADAPT	How do I adapt parts of this design into my design?
SYNTH	How do I interpret this feedback?
TEAM	How do I work with my teammates effectively?
STAKE	How do I work with clients and stakeholders effectively?
LIMIT	How do I design with limited resources?
SCOPE	How do I scope this design problem?
STAGE	When should I move to the next design stage?
EVAL	How can I choose between options?
BIAS	How can I avoid biasing my design?
DIVRS	How do I design for diversity?
ID	Am I the kind of person that can or should do design?
WARP	Students hold inaccurate perceptions of design.
STUCK	Students fixate on conventional design patterns.
RUSH	Students rush to implement and discount design work.

Table 1: The set of student learning difficulties in HCI education identified in our prior investigation.

However, identification of these difficulties is only the first step to improving HCI pedagogy. There remain a number of open questions around how to most effectively *use* the knowledge of these learning difficulties, such as:

- How do these learning difficulties manifest across different educational contexts?
- What are effective strategies for mitigating these risks to learning?
- How can we best design curricula and lessons that avoid these difficulties?

For more details, a preprint of our paper can be found at https://alannaholeson.com/papers/chi2020_HCILearningDiffs_final_tagged.pdf

- How can we leverage this knowledge to help novice HCI educators prepare to teach software interface design concepts in HCI contexts?
- How do students perceive these difficulties, and might there be more or less equitable ways to support students in navigating these barriers?

Unsolved Challenge: Developing a Robust Body of HCI Pedagogical Content Knowledge

The answers to the above questions form the basis for developing HCI pedagogical content knowledge, or PCK. PCK originally arose to help explain the differences between "good" and "great" teachers [23]. PCK is domain-specific [10, 12, 14] and consists of knowledge of pedagogical strategies to teach a particular topic, in a particular context, to a particular audience. Recent work from STEM education suggests that teachers with better-developed PCK for their topic of instruction often see evidence of better learning outcomes [4], even when teachers have exceptionally high content expertise (such as in higher education) [7]. Exact definitions of the components of PCK vary (c.f. [1, 8, 19]), but knowledge of student learning difficulties, such as those referenced above, is generally considered a core aspect.

Though our field has begun to explore the nature of computing PCK within the past decade (c.f. [9, 12, 15, 18, 20, 27, 29]), very little of this work focuses specifically on the development of HCI PCK. Given the benefits to learning a robust body of PCK can provide, it seems important that we give consideration to developing PCK specifically for the learning and teaching of HCI concepts. Further, given the domain-specificity of PCK, we can reasonably expect HCI PCK to differ significantly from PCK for traditional CS concepts. Exploring this space may enable the development of more effective learning materials (a boon in today's HCI classes, which are often short on time [3]) or help shorten onboarding time for novice HCI educators—an important pursuit to ensure we have enough teachers to keep pace with the rapid growth of computing education.

How the EduCHI Community Can Help

Rarely do HCI practitioners and researchers have the opportunity to come together and direct their collective attention toward a particular unsolved challenge facing the field. We propose to take advantage of this opportunity by introducing intriguing questions similar to the above bulleted list to the participants attending this year's EduCHI symposium, then asking the community to brainstorm along those lines of inquiry. With our collective expertise, the EduCHI community represents multiple, diverse, global perspectives on HCI education, which will likely lead to rich and nuanced discussion as each member brings their own viewpoint into the proceedings. We hope that the results of the afternoon's session will at the very least encourage collaboration and provide future research agendas for moving the field of HCI forward. If participants are interested, there is also high potential for the outcomes of the day's session to result in a future publication or article, which would help ensure that all members of the EduCHI community, even those who could not make it to the 2020 symposium, could benefit. Either way, symposium atendees who wish to engage with this discussion will likely leave with an improved understanding of the ways that learning difficulties can manifest in their own classes as well as some ideas on how to mitigate the resulting risks to learning and teaching which arise.

REFERENCES

[1] John D Bransford, Ann L Brown, Rodney R Cocking, and others. 2000. *How People Learn*. Vol. 11. Washington, DC: National academy press.

[2] Robin Braun, Wayne Brookes, Roger Hadgraft, and Zenon Chaczko. 2019. Assessment Design for Studio-Based Learning. In *Proceedings of the Twenty-First Australasian Computing Education Conference (ACE '19)*. ACM, New York, NY, USA, 106–111. DOI: http://dx.doi.org/10.1145/3286960.3286973

[3] Elizabeth F. Churchill, Anne Bowser, and Jennifer Preece. 2013. Teaching and Learning Human-computer Interaction: Past, Present, and Future. *interactions* 20, 2 (March 2013), 44–53. DOI: http://dx.doi.org/10.1145/2427076.2427086

[4] Rebecca Cooper, John Loughran, and Amanda Berry. 2015. Science Teachers' PCK. *Berry, A., Friedrichsen, P. & Loughran, J., Re-examining Pedagogical Content Knowledge in Science Education* (2015), 60–74.

[5] Alistair D. N. Edwards, Peter Wright, and Helen Petrie. 2006. HCI education: We are failing - why?. In *Proceedings of HCI Educators Workshop 2006*. 23–24.

[6] Anthony Faiola. 2007. The Design Enterprise: Rethinking the HCI Education Paradigm. *Design Issues* 23, 3 (2007), 30–45. DOI: http://dx.doi.org/https://doi.org/10.1162/desi.2007.23.3.30

[7] Juan-Miguel Fernandez-Balboa and Jim Stiehl. 1995. The Generic Nature of Pedagogical Content Knowledge Among College Professors. *Teaching and teacher education* 11 (1995), 293–306. DOI: http://dx.doi.org/https://doi.org/10.1016/0742-051X(94)00030-A

[8] Julie Gess-Newsome. 1999. Pedagogical Content Knowledge: An Introduction and Orientation. In *Examining Pedagogical Content Knowledge: The Construct and its Implications for Science Education*, Julie Gess-Newsome and Norman G. Lederman (Eds.). Springer Netherlands, Dordrecht, 3–17. DOI: http://dx.doi.org/10.1007/0-306-47217-1_1

[9] Susannah Go and Brian Dorn. 2016. Thanks for Sharing: CS Pedagogical Content Knowledge Sharing in Online Environments. In *Proceedings of the 11th Workshop in Primary and Secondary Computing Education - WiPSCE '16*. ACM Press, Münster, Germany, 27–36. DOI: http://dx.doi.org/10.1145/2978249.2978253

[10] Jan H. van Driel, Nico Verloop, and Wobbe de Vos. 1998. Developing Science Teachers' Pedagogical Content Knowledge. *Journal of Research in Science Teaching - J RES SCI TEACH* 35 (1998), 673–695. DOI:http://dx.doi.org/https://doi.org/10.1002/(SICI)1098-2736(199808)35:6<673::AID-TEA5>3.0.CO;2-J

[11] Chenglie Hu. 2016. Can Students Design Software?: The Answer Is More Complex Than You Think. In *Proceedings of the 47th ACM Technical Symposium on Computing Science Education (SIGCSE '16)*. ACM, New York, NY, USA, 199–204. DOI: http://dx.doi.org/10.1145/2839509.2844563

[12] Peter Hubwieser, Marc Berges, Johannes Magenheim, Niclas Schaper, Kathrin Bröker, Melanie Margaritis, Sigrid Schubert, and Laura Ohrndorf. 2013. Pedagogical Content Knowledge for Computer Science in German Teacher Education Curricula. In *Proceedings of the 8th Workshop in Primary and Secondary Computing Education (WiPSE '13)*. ACM, New York, NY, USA, 95–103. DOI: http://dx.doi.org/10.1145/2532748.2532753 event-place: Aarhus, Denmark.

[13] C. D. Hundhausen, D. Fairbrother, and M. Petre. 2012. An Empirical Study of the "Prototype Walkthrough": A Studio-Based Activity for HCI Education. *ACM Transactions on Computer-Human Interaction (TOCHI)* 19, 4 (Dec. 2012), 26:1–26:36. DOI: http://dx.doi.org/10.1145/2395131.2395133

[14] N. H. Ibrahim, J. Surif, A. H. Abdullah, and N. A. S. Sabtu. 2014. Comparison of Pedagogical Content Knowledge between Expert and Novice Lecturers in Teaching and Learning Process. In *2014 International Conference on Teaching and Learning in Computing and Engineering*. 240–246. DOI: http://dx.doi.org/10.1109/LaTiCE.2014.53

[15] Yvonne Kao, Katie D'Silva, Aleata Hubbard, Joseph Green, and Kimkinyona Cully. 2018. Applying the Mathematical Work of Teaching Framework to Develop a Computer Science Pedagogical Content Knowledge Assessment. In *Proceedings of the 49th ACM Technical Symposium on Computer Science Education (SIGCSE '18)*. ACM, New York, NY, USA, 888–893. DOI:http://dx.doi.org/10.1145/3159450.3159521

[16] Sarah Lewthwaite and David Sloan. 2016. Exploring Pedagogical Culture for Accessibility Education in Computing Science. In *Proceedings of the 13th Web for All Conference (W4A '16)*. ACM, New York, NY, USA, 3:1–3:4. DOI: http://dx.doi.org/10.1145/2899475.2899490

[17] D. Scott McCrickard, C. M. Chewar, and Jacob Somervell. 2004. Design, Science, and Engineering Topics?: Teaching HCI with a Unified Method. In *Proceedings of the 35th SIGCSE technical symposium on computer science education (SIGCSE '04)*. ACM, New York, NY, USA, 31–35. DOI: http://dx.doi.org/10.1145/971300.971314

[18] Tom McKlin, Taneisha Lee, Dana Wanzer, Brian Magerko, Doug Edwards, Sabrina Grossman, Emily Bryans, and Jason Freeman. 2019. Accounting for Pedagogical Content Knowledge in a Theory of Change Analysis. In *Proceedings of the 2019 ACM Conference on International Computing Education Research (ICER '19)*. ACM, New York, NY, USA, 157–165. DOI: http://dx.doi.org/10.1145/3291279.3339412

[19] Punyashloke Mishra and Matthew J. Koehler. 2006. Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. DOI:http://dx.doi.org/10.1111/j.1467-9620.2006.00684.x

[20] Laura Ohrndorf and Sigrid Schubert. 2013. Measurement of Pedagogical Content Knowledge: Students' Knowledge and Conceptions. In *Proceedings of the 8th Workshop in Primary and Secondary Computing Education (WiPSE '13)*. ACM, New York, NY, USA, 104–107. DOI: http://dx.doi.org/10.1145/2532748.2532758 event-place: Aarhus, Denmark.

[21] Alannah Oleson, Meron Solomon, and Amy J. Ko. 2020. Computing Students' Learning Difficulties in HCI Education. In *ACM CHI 2020 Conference on Human Factors in Computing Systems*. 14. DOI: http://dx.doi.org/10.1145/3313831.3376149

[22] Yolanda Jacobs Reimer and Sarah A. Douglas. 2003. Teaching HCI Design with the Studio Approach. *Computer science education* 13, 3 (2003), 191–205.

[23] Lee Shulman. 1987. Knowledge and Teaching: Foundations of the New Reform. *Harvard educational review* 57, 1 (1987), 1–23. DOI: http://dx.doi.org/https://doi.org/10.17763/haer.57.1.j463w79r56455411

[24] Charles Thevathayan and Margaret Hamilton. 2017. Imparting Software Engineering Design Skills. In *Proceedings of the Nineteenth Australasian Computing Education Conference (ACE '17)*. ACM, New York, NY, USA, 95–102. DOI: http://dx.doi.org/10.1145/3013499.3013511

[25] Harold Thimbleby. 2009. Teaching and Learning HCI. In *Universal Access in Human-Computer Interaction. Addressing Diversity (Lecture Notes in Computer Science)*, Constantine Stephanidis (Ed.). Springer Berlin Heidelberg, 625–635.

[26] Nicholas True, Jeroen Peeters, and Daniel Fallman. 2013. Confabulation in the Time of Transdisciplinarity: Reflection on HCI Education and a Call for Conversation. In *Human-Computer Interaction. Human-Centred Design Approaches, Methods, Tools, and Environments (Lecture Notes in Computer Science)*, Masaaki Kurosu (Ed.). Springer Berlin Heidelberg, 128–136.

[27] Rebecca Vivian and Katrina Falkner. 2019. Identifying Teachers' Technological Pedagogical Content Knowledge for Computer Science in the Primary Years. In *Proceedings of the 2019 ACM Conference on International Computing Education Research (ICER '19)*. ACM, New York, NY, USA, 147–155. DOI: http://dx.doi.org/10.1145/3291279.3339410 event-place: Toronto ON, Canada.

[28] Lauren Wilcox, Betsy DiSalvo, Dick Henneman, and Qiaosi Wang. 2019. Design in the HCI Classroom: Setting a Research Agenda. In *Proceedings of the 2019 on Designing Interactive Systems Conference (DIS '19)*. ACM, New York, NY, USA, 871–883. DOI: http://dx.doi.org/10.1145/3322276.3322381

[29] Aman Yadav and Marc Berges. 2019. Computer Science Pedagogical Content Knowledge: Characterizing Teacher Performance. *ACM Trans. Comput. Educ.* 19, 3 (May 2019), 29:1–29:24. DOI: http://dx.doi.org/10.1145/3303770

[30] Helen Z. Zhang, Charles Xie, and Saeid Nourian. 2018. Are Their Designs Iterative or Fixated? Investigating Design Patterns from Student Digital Footprints in Computer-Aided Design Software. *International Journal of Technology and Design Education* 28, 3 (Sept. 2018), 819–841. DOI: http://dx.doi.org/10.1007/s10798-017-9408-1