Gender Biases in Software for Problem-Solving

Margaret Burnett[1], Anita Sarma[1], Christopher Mendez[1],
Alannah Oleson[1,2], Claudia Hilderbrand[1], Zoe Steine-Hanson[1], Amy J. Ko[2]

[1]Oregon State University
Corvallis, Oregon

[2]University of Washington
Seattle, Washington

{burnett,anita.sarma,mendezc,olesona,minic,steinehz}@oregonstate.edu, ajko@uw.edu

***Abstract*—The workshop call raises the question of how we can help users problem-solve, especially when the problem to be solved is complex. One answer to this question is to change the way we go about building such systems. Why: most software has extensive biases against certain cognitive problem-solving styles—especially those styles preferred by more women than men. In this position paper, we consider the workshop call's discussion questions from the perspective of GenderMag, a method to pinpoint gender biases in user-facing software that aims to help people problem-solve.**

Keywords—GenderMag, gender biases, problem-solving

I. Introduction

In raising the issue of how we can help users' problem solve, the workshop call suggested a number of questions for discussion. Among them were the following:

- Diversity: What provisions should be made to promote diverse community engagement in problem solving, designing for inclusion across identities as they may relate to aspects such as socio-economic status, gender, culture, etc.?
- Workflows: What social structures and workflows may need to be supported?
- Education/Training: How should students and professionals be educated and trained in order to be able to function most productively in these new human-technical environments for problem solving?

In this position paper, we consider these questions from the perspective of gender biases that affect problem-solving.

II. GenderMag: Diversity and Workflows

We have been working on a method that aims at the first two questions above, Diversity and Workflows. The GenderMag method (Gender Inclusiveness Magnifier) [8] captures individuals' diversity in cognitive styles, especially those styles that tend to cluster by gender. Using this method, software teams can pinpoint gender biases relating to problem-solving styles in the software they are building that tries to support people's problem-solving activities. To the best of our knowledge, no other walkthrough methods contain this focus on diversity of cognitive styles.

GenderMag's foundations lie in research on how people's individual problem-solving strategies sometimes cluster by gender. GenderMag focuses on five facets of problem-solving:

(1) Motivations: More women than men are motivated to use technology for what it helps them accomplish, whereas more men than women are motivated by their interest in technology itself [1, 4, 6, 11, 18, 21, 23, 24, 36].

(2) *Information processing styles*: Problem-solving with software often requires information gathering, and more women than men gather information comprehensively—gathering fairly complete information before proceeding—but more men than women use selective styles—following the first promising information, then backtracking if needed [9, 14, 28, 29, 33].

(3) *Computer self-efficacy:* Women often have lower computer self-efficacy (confidence) than their male peers, and this can affect their behavior with technology [1, 2, 3, 4, 6, 17, 19, 22, 24, 30, 32, 37].

(4) *Risk aversion:* Women tend statistically to be more risk-averse than men [13, 16, 39], and risk aversion can impact users' decisions as to which feature sets to use.

(5) *Styles of Learning Technology:* Women are statistically more likely to prefer learning software features in process-oriented ways, and less likely than men to prefer learning new software features by playfully experimenting ("tinkering") [3, 4, 10, 12, 21, 34].

A user with any of these differences in cognitive styles is at a disadvantage when not supported by the software.

GenderMag brings these facets to life with a set of four faceted personas—"Abby", "Pat(ricia)", "Pat(rick)" and "Tim" (Fig. 1). Each persona's mission is to represent a subset of a system's target users as they relate to these five facets.

GenderMag intertwines these personas with a specialized Cognitive Walkthrough (CW) [38, 40]. The CW is a long-standing inspection method for identifying usability issues for new users to a program or feature. In a GenderMag CW,

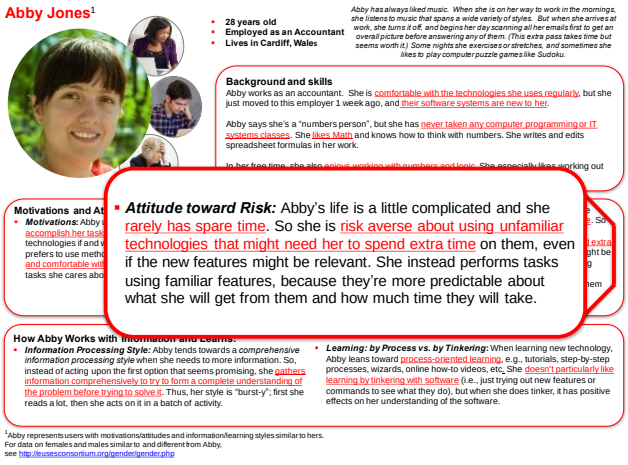

Fig. 1. Abby is a "multi-persona", meaning that she has multiple appearances and demographic portions of her are customizable [31]. One of the facets is blown up for legibility.

To appear in: Designing Technologies to Support Human Problem Solving: Workshop at VL/HCC 2018 on Oct. 1, 2018.

evaluators choose a persona, then answer a question about each subgoal the persona might have in a detailed use-case, and two CW questions about each action. The evaluators answer's should be based on the persona's five facets.

The questions are:

SubgoalQ: Will <persona> have formed this subgoal as a step to their overall goal? (Yes/no/maybe, why)
ActionQ1: Will <persona> know what to do at this step? (Yes/no/maybe, why)
Action Q2: If <persona> does the right thing, will s/he know s/he did the right thing & is making progress toward their goal? (Yes/no/maybe, why)

After completing all steps in the use case, evaluators review their answers to the above questions to find no or maybe answers. This tells evaluators what steps would cause the persona to fail the task, and where fixes should be made. If a no or maybe answer is also tied to one or more facets, then evaluators know they also have a gender bias issue in their software.

Evaluations of GenderMag's validity and effectiveness have produced strong results [5, 7, 8, 15, 20, 25, 26, 35]. For example, GenderMag evaluations across multiple companies identified a high number of gender inclusiveness issues (Fig. 2) [7]. Further field research has found that GenderMag can help not only identify gender inclusiveness issues but also change the mindset of software designers, helping them avoid gender inclusiveness issues in the first place [5]. Research has also found that software evaluated and fixed with GenderMag shows improvement in user performance [5].

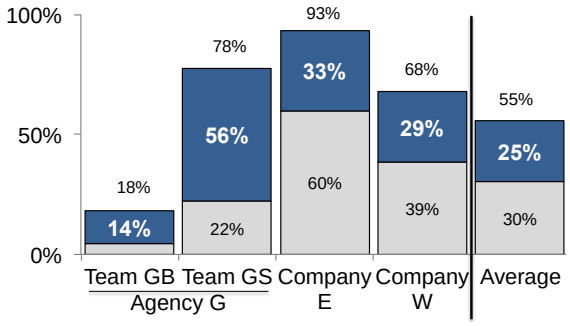

Fig. 2: Issues each team in a field study found as a percentage of the number of user actions and subgoals evaluated. Above bars: total issues. Dark blue: gender-inclusiveness issues. Light gray: other issues.

III. GenderMag in Education, Training, Integrating into the "Day Job"

One issue with current diversity and inclusion approaches is that they tend to be isolated from other activities in education environments and workplaces. For example, there are special committees on diversity and inclusion, special training sessions on diversity and inclusion, special CS classes on ethics/social issues of computing, and so on. One of our goals is to find ways to *integrate* support for diverse problem-solving into students' everyday education and work tasks.

To help mainstream support for diversity and inclusion into software through CS education, we are working on adding notions of supporting diverse cognitive styles into mainstream CS classes in higher education. We posit that integrating education on how to design for diverse cognitive styles into classes that teach design can help to show that supporting diverse problem-solving styles is *part of* software design, not something "extra".

Toward this end, in a collaboration between Oregon State University and University of Washington, and with the help of nine teacher-researchers across the U.S., we embarked upon an investigation of how to teach the GenderMag method in ways that integrate gender-inclusive software design into CS courses [31]. Analysis of the teachers' observations and experiences, the materials they used, direct observations of students' behaviors, and multiple data on the students' own reflections on their learning revealed 11 components of pedagogical knowledge that affect teaching GenderMag in CS classes. These include strategies for anticipating and addressing resistance to the topic of inclusion, strategies for modeling and scaffolding perspective taking, and strategies for tailoring instruction to students' prior beliefs and biases.

The GenderMag-Teach effort is a community, and we invite all interested educators to join us at its community wiki (Fig. 3), which contains downloadable, educator-contributed materials to support educators' efforts in this direction. (http://gendermag.org, then click on the Teaching link.)

IV. GenderMag's Open Source Tool

For people not in education environments— or for those who simply prefer experiential learning over classroom learning— we have developed a GenderMag Recorder's Assistant tool [27]. The tool not only semi-automates software professionals' use of GenderMag, it also walks them through evaluations of the user-facing software they are creating, step-by-step, hands-on.

To use the Recorder's Assistant, a software team navigates via the browser to the app or mockup they want to evaluate, then starts the tool from the browser menu. The main sequence is to

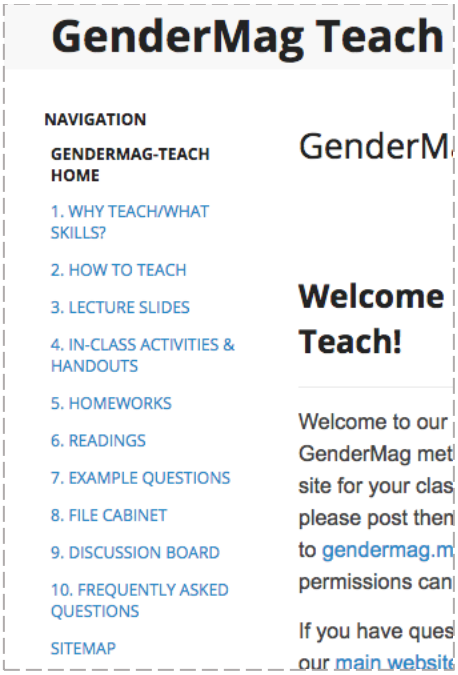

Fig. 3: Structure of the GenderMag-Teach community wiki. Available in full at the GenderMag site (http://gendermag.org/).

view a persona (Fig. 4(c)) and proceed through the scenario of their choice from the persona's perspective, one action at a time. At each step, the tool's "context-specific capture" captures screenshots about the action the team selects (Fig. 4(a)), and records the answers to questions about it (Fig. 4(b)). The tool saves this sequence of screenshots and questions/answers to form a gender-bias "bug report."

The Recorder's Assistant is freely available on Open Source, and anyone can download it and/or contribute to it (http://gendermag.org, click on the Tool link).

V. Discussion

We believe that increasing GenderMag practices in industry can have a significant impact on software's effectiveness with diverse populations. One avenue toward this end can be teaching GenderMag to experienced and new software developers alike. Through efforts like these, we hope to change the mindset of software developers to be more inclusive, and eventually to make inclusive design part of all software design.

Many open questions remain about the barriers that diverse populations face in problem solving. For example, are people's processes of formulating problems as cognitively diverse as their processes of solving problems? Will software designed for collaboration pose different issues for cognitive diversity than software intended for individual usage? Such questions are best answered by a community of researchers, not just a single group. Perhaps this workshop will help to build such a community.

VI. Calls to Action

This position paper is a call to action: in researching ways to help people problem-solve, we must all keep in mind diversity of cognitive styles. Cognitive diversity is what makes teams, businesses, and society the most effective they can be in solving problems. Also, in more concrete calls to action, we invite you to http://gendermag.org to join our collaborations to create better software and better education for everyone.

Fig. 4: The Recorder's Assistant tool during an evaluation of a mobile time-and-scheduling app. (Left): The app being evaluated is displayed with (a) a rectangle around the action the evaluators are deciding if a user like "Abby" will take. (Right): A blow-up of portions of the GenderMag features for the app: (b) the GenderMag question the team is answering at the moment, including a checklist of Abby's facets; and (c) a summary of the persona the team has decided to use (in this case, Abby).

Acknowledgments

This work has been supported in part by NSF grants 1528061, 1559657, 1560526, 1703304, and 1735123.

References

[1] L. Beckwith and M. Burnett, Gender: An important factor in end-user programming environments? IEEE VL/HCC, pp. 107-114, 2004.

[2] L. Beckwith, M. Burnett, S. Wiedenbeck, C. Cook, S. Sorte, and M. Hastings, Effectiveness of end-user debugging software features: Are there gender issues? ACM CHI, pp. 869-878, 2005.

[3] L. Beckwith, C. Kissinger, M. Burnett, S. Wiedenbeck, J. Lawrance, A. Blackwell, and C. Cook, Tinkering and gender in end-user programmers' debugging, ACM CHI, pp. 231-240, 2006.

[4] M. Burnett, L. Beckwith, S. Wiedenbeck, S. D. Fleming, J. Cao, T. H. Park, V. Grigoreanu, and K. Rector, Gender pluralism in problem-solving software, Interacting with Computers 23(5), pp. 450–460, 2011.

[5] M. Burnett, R. Counts, R. Lawrence, H. Hanson, Gender HCI and Microsoft: Highlights from a longitudinal study, IEEE VLHCC, pp. 139-143, 2017.

[6] M. Burnett, S. D. Fleming, S. Iqbal, G. Venolia, V. Rajaram, U. Farooq, V.Grigoreanu, and M. Czerwinski, Gender differences and programming environments: Across programming populations, IEEE Symp. Empirical Soft. Eng. and Measurement, Article 28 (10 pages), 2010.

[7] M. Burnett, A. Peters, C. Hill, and N. Elarief, Finding gender inclusiveness software issues with GenderMag: A field investigation, ACM CHI, pp. 2586-2598, 2016.

[8] M. Burnett, S. Stumpf, J. Macbeth, S. Makri, L. Beckwith, I. Kwan, A. Peters, and W. Jernigan, GenderMag: A method for evaluating software's gender inclusiveness. Interacting with Computers 28(6), pp. 760-787, 2016.

[9] P. Cafferata and A. M. Tybout, Gender differences in information processing: a selectivity interpretation, in Cognitive and Affective Responses to Advertising, Lexington Books, 1989.

[10] J. Cao, K. Rector, T. Park, S. Fleming, M. Burnett, and S. Wiedenbeck, A debugging perspective on end-user mashup programming, IEEE VLHCC, pp. 149-159, 2010.

[11] J. Cassell, Genderizing HCI, In The Hand-book of Human-Computer Interaction, M.G. Helander, T.K. Landauer, and P.V. Prabhu (eds.). L. Erlbaum Associates Inc., pp. 402-411, 2002.

[12] S. Chang, V. Kumar, E. Gilbert, and L. Terveen, Specialization, homophily, and gender in a social curation site: findings from Pinterest, ACM CSCW, pp. 674-686, 2014.

[13] G. Charness and U. Gneezy, Strong evidence for gender differences in risk taking, J. Economic Behavior & Organization 83(1), pp. 50–58, 2012.

[14] C. Coursaris, S. Swierenga, and E. Watrall, An empirical investigation of color temperature and gender effects on web aesthetics, J. Usability Studies 3(3), pp. 103-117, May 2008.

[15] S. Cunningham, A. Hinze and D. Nichols, Supporting gender-neutral digital library creation: A case study using the GenderMag Toolkit, Digital Libraries: Knowledge, Information, and Data in an Open Access Society, pp. 45-50, 2016.

[16] T. Dohmen, A. Falk, D. Huffman, U. Sunde, J. Schupp, G. Wagner. Individual risk attitudes: Measurement, determinants, and behavioral consequences, J. European Econ. Assoc. 9(3), pp. 522–550, 2011.

[17] A. Durndell and Z. Haag, Computer self efficacy, computer anxiety, attitudes towards the Internet and reported experience with the Internet, by gender, in an East European sample, Computers in Human Behavior 18, pp. 521–535, 2002.

[18] J. Hallström, H. Elvstrand, and K. Hellberg, Gender and technology in free play in Swedish early childhood education, Int. J. Technology and Design Education 25(2), pp. 137-149, 2015.

[19] K. Hartzel, How self-efficacy and gender issues affect software adoption and use, Commun. ACM 46(9), pp. 167–171, 2003.

[20] C. Hill, M. Haag, A. Oleson, C. Mendez, N. Marsden, A, Sarma, and M. Burnett, Gender-inclusiveness personas vs. stereotyping: Can we have it both ways? ACM CHI, pp.6658-6671, 2017.

[21] W. Hou, M. Kaur, A. Komlodi, W. Lutters, L. Boot, S. Cotten, C. Morrell, A. Ant Ozok, and Z. Tufekci, Girls don't waste time: Pre-adolescent attitudes toward ICT, ACM CHI, pp. 875-880, 2006.

[22] A. Huffman, J. Whetten, and W. Huffman, Using technology in higher education: The influence of gender roles on technology self-efficacy, Computers in Human Behavior 29(4), pp. 1779–1786, 2013.

[23] C. Kelleher, Barriers to programming engagement, Advances in Gender and Education 1, pp. 5-10, 2009.

[24] J. Margolis and A. Fisher, Unlocking the Clubhouse: Women in Computing, MIT Press, 2003.

[25] N. Marsden and M. Haag, Evaluation of GenderMag personas based on persona attributes and persona gender, HCI International 2016 – Posters' Extended Abstracts: Proceedings Part I, pp. 122-127, 2016.

[26] C. Mendez, H. S. Padala, Z. Steine-Hanson, C. Hilderbrand, A. Horvath, C. Hill, L. Simpson, N. Patil, A. Sarma, M. Burnett, Open Source barriers to entry, revisited: A sociotechnical perspective, ACM/IEEE ICSE 2018.

[27] Christopher Mendez, Zoe Steine Hanson, Alannah Oleson, Amber Horvath, Charles Hill, Claudia Hilderbrand, Anita Sarma, Margaret Burnett, Semi-Automating (or not) a Socio-Technical Method for Socio-Technical Systems, IEEE VL/HCC, 2018 (to appear).

[28] J. Meyers-Levy, B. Loken, Revisiting gender differences: What we know and what lies ahead, J. Consumer Psychology 25(1), pp. 129-149, 2015.

[29] J. Meyers-Levy, D. Maheswaran, Exploring differences in males' and females' processing strategies, J. Consumer Research 18, pp. 63–70, 1991.

[30] A. O'Leary-Kelly, B. Hardgrave, V. McKinney, and D. Wilson, The influence of professional identification on the retention of women and racial minorities in the IT workforce, NSF Info. Tech. Workforce & Info. Tech. Res. PI Conf., pp. 65-69, 2004.

[31] Alannah Oleson, Christopher Mendez, Zoe Steine-Hanson, Claudia Hilderbrand, Christopher Perdriau, Margaret Burnett, Amy Ko, Pedagogical Content Knowledge for Teaching Inclusive Design, Pedagogical Content Knowledge for Teaching Inclusive Design. ACM ICER, 2018, 9 pages (to appear).

[32] Piazza Blog, STEM confidence gap. Retrieved September 24th, 2015, http://blog.piazza.com/stem-confidence-gap/

[33] R. Riedl, M. Hubert, and P. Kenning, Are there neural gender differences in online trust? An fMRI study on the perceived trustworthiness of EBay offers, MIS Quarterly 34(2), pp. 397-428, 2010.

[34] D. Rosner and J. Bean, Learning from IKEA hacking: I'm not one to decoupage a tabletop and call it a day, ACM CHI, pp. 419-422, 2009.

[35] A. Shekhar and N. Marsden. Cognitive Walkthrough of a learning management system with gendered personas. 4th Gender & IT Conference (GenderIT'18), pp. 191-198, 2018. doi:10.1145/3196839.3196869

[36] S. Simon, The impact of culture and gender on web sites: An empirical study, The Data Base for Advances in Information Systems 32, pp. 18-37, 2001.

[37] A. Singh, V. Bhadauria, A. Jain, and A. Gurung, Role of gender, self-efficacy, anxiety and testing formats in learning spreadsheets, Computers in Human Behavior 29(3), pp. 739–746, 2013.

[38] R. Spencer, The streamlined cognitive walkthrough method, working around social constraints encountered in a software development company, ACM CHI, pp. 353-359, 2000.

[39] E. Weber, A. Blais, and N. Betz, A domain-specific risk-attitude scale: Measuring risk perceptions and risk behaviors, J. Behavioral and Decision Making 15, pp. 263-290, 2002.

[40] C. Wharton, J. Rieman, C. Lewis, and P. Polson, The cognitive walkthrough method: A practitioner's guide. In Usability Inspection Methods, pp. 105-140, 1994.