Two Elements of Pair Programming Skill

Franz Zieris
Institut für Informatik
Freie Universität Berlin
Berlin, Germany
zieris@inf.fu-berlin.de

Lutz Prechelt
Institut für Informatik
Freie Universität Berlin
Berlin, Germany
prechelt@inf.fu-berlin.de

Abstract—Background: Pair programming (PP) can have many benefits in industry. Researchers and practitioners recognize that successful and productive PP involves some skill that might take time to learn and improve.

Question: What are the elements of pair programming skill?

Method: We perform qualitative analyses of industrial pair programming sessions following the Grounded Theory Methodology. We look for patterns of problematic behavior to conceptualize key elements of what ‘good’ and ‘bad’ pairs do differently.

Results: Here, we report two elements of pair programming skill: Good pairs (1) manage to maintain their Togetherness and (2) keep an eye on their session’s Expediency. We identify three problematic behavioral patterns that affect one or both of these elements: Getting Lost in the Weeds, Losing the Partner, and Drowning the Partner.

Conclusion: Pair programming skill is separate from general software development skill. Years of PP experience are neither a prerequisite nor sufficient for successful pair programming.

I. INTRODUCTION

Pair programming (PP) is the practice of two software developers working closely together on one machine. Kent Beck characterizes it as “a dialog between two people trying to [...] program (and analyze and design and test)” which “is a subtle skill, one that you can spend the rest of your life getting good at” [2, p. 100]. Beck sees many benefits in this practice, such as higher code quality in less time [2, pp. 66–67]. He does not, however, elaborate on the aspects of the “skill” underlying these benefits; he merely alludes to the importance of communication and coordination [2, p. 141].

Much of pair programming research appears to be built on the assumption that PP does not involve any particular skill beyond general software development experience: A large experiment by Arisholm et al. [1], for instance, was set to determine PP’s effect on code quality and effort for junior, intermediate, and expert developers, but 93 of its 98 subject pairs had no prior pairing experience at all. A meta-analysis of PP effectiveness [7] later found only weak effects and high between-study variance, which indicates a number of not-understood (and hence uncontrolled) moderating factors including the “amount of training in pair programming” [3, Sec. 4], which the researchers expect to have a positive effect on pair performance.

To understand the differences between skillful and problematic pair programming, we perform qualitative analyses of industrial PP sessions. Here, we report two elements of PP skill we identified. We discuss related work in Section II and characterize our data and explain our research method in Section III, sketch our findings in Section IV, and provide a discussion and an outlook in Sections V and VI.

II. RELATED WORK

A. On the Existence of Pair Programming Skill

In the context of her PP experiments with students, Williams [10] describes the process of pair jelling as the transition of two individuals from “considering themselves as a two-programmer team” to “considering themselves as one coherent, intelligent organism working with one mind” [10, p. 53]. Such jelling appears to have two aspects: Individuals get accustomed to not working alone [11, p. 22], and a specific pair gets to know each other in order for some “bonding” to happen [10, p. 101]. Williams does not explicate what this phase entails or how long it takes, but she claims the student pairs were jelled after their first experiment assignment [10, pp. 63–64].

From an industry context, practitioner Belshee reports that “[i]t often takes days for a given pair to be comfortable with each other”, which he describes as a precondition for a pair being able to reach a state of highly productive “Pair Flow” in which both members have a shared understanding of their task [3, Sec. 1.2]. Belshee does not, however, mention what or how long it takes to get good at pair programming.

Bryant et al. [4, 5] analyzes the abstraction level of utterances in the dialog of pair programmers in industry and note that there are differences between the pair member sitting at the keyboard and her partner—but only for pairs with less than six months of PP experience: The frequencies and types of utterances of “expert pair programmers” do not depend on who controls the keyboard [4, Sec. 5.2]. Bryant et al. conclude that in experienced pairs, both partners maintain a “clear mental model of [the pair’s] current state” [5, Sec. 6.3].

B. On the Elements of Pair Programming Skill

While there is some awareness in the literature that two developers are not suddenly more productive just because they are placed next to each other, there has been only little research into the elements that make pair programming work. In their ethnographic study, Chong & Hurlbutt [6] report that two partners with a similar level of task-relevant expertise can become “tightly coupled” such that they do not even need complete sentences for effective communication. However,
with a large-enough expertise difference between them, the more knowledgable partner will be dominant.

For the aspect of transferring knowledge during pair programming, both Plonka et al. [8] and Ziers & Prechelt [12], [13] summarize a number of ‘expertly’ pair programming behaviors, including: Making one’s thinking process visible [8], [13], letting the learner work something out on her own [8], letting the explainer finish her thoughts [12], and making sure to deal with complex topics completely [12].

III. RESEARCH METHOD

A. Research Goal and Data Collection

The overall goal of our research is to understand how ‘good’ and ‘bad’ pair programming sessions differ. Ultimately, we want to provide actionable advice for practitioners. Here, we want to understand the elements of the skill which pair programmers exhibit in successful sessions and how sessions suffer from a lack thereof.

The industrial data used by Bryant et al. [4], [5] is limited to audio recordings, which makes it difficult to understand what the developers are referring to: For one out of every eight utterances, the researchers could not reconstruct what the pairs referred to [5, Sec. 5.1]. We therefore analyze industrial PP sessions comprising audio, webcam, and screencast from the PP-ind repository [13, 16], which contains a variety of over 60 everyday PP sessions from 13 companies along with pre- and post-session questionnaires filled out by the developers. Sessions from the repository have IDs like ‘CA2’ (session 2, from the first team A, at the third company C); developers are numbered similarly, e.g. ‘C2’.

B. Qualitative Research Approach

We follow Strauss’ & Corbin’s Grounded Theory Methodology [9]. In particular, we perform theoretical sampling [9, Ch. 11] by choosing sessions from the repository with pair members who have been pair-programming regularly for years and those that are new to the practice, as well as involving experienced software developers and novices (see Table II). Below, we report our findings mostly from open coding [9, Ch. 5], where relevant phenomena in the data are identified, analyzed, and characterized through concepts, and some findings from axial coding [9, Ch. 7], which investigates when and how these phenomena occur and how the pair deals with them. We did not yet perform selective coding [9, Ch. 8] to formulate a theory and also did not yet reach theoretical saturation [9, p. 188].

C. Our Notions of ‘Good’ and ‘Bad’

We only assess exhibited PP skill, not the developers’ potential and not behavior changes over a longer time. This is also a purely qualitative study. We use a deficit-oriented perspective, i.e., we analyze episodes of pairs running into ‘trouble’, e.g., (a) one or both pair members getting frustrated because they do not understand what their partner says or does, or (b) the pair doing things that help neither with their actual task nor with some overarching goal such as getting familiar with the code base.

IV. RESULTS

We first describe two elements of pair programming skill (Togetherness and Expediency) and then characterize three patterns of problematic behavior in pair programming sessions: (Getting Lost in the Weeds, Losing the Partner, and Drowning the Partner). We illustrate each pattern with excerpts from actual sessions.

Section IV-E then gives examples of the alternate (high-skill) case, where pairs manage to avert these problems.

A. Two Elements of Pair Programming Skill

Togetherness. Good pairs manage to stay together, that is, to establish and maintain a shared mental model throughout their session. They detect and address relevant discrepancies in each other’s understanding of their task, work state, software system, and software development in general.

Expediency. Good pairs balance short-term goals, such as identifying a defect or implementing a new feature, and long-term goals, e.g., addressing any member’s knowledge gaps.

B. Anti-Pattern: Getting Lost in the Weeds

Two developers may come up with more ideas on what to look up and how to proceed than a single developer. But pairs risk Getting Lost in the Weeds when they jump on too many of them with too little consideration. Such pairs may manage to Stay Together in that they both think about all these new ideas together, but they risk thinking too much about irrelevant details, losing track of what is important, and thus reduce their Expediency.

Example 1: Session DA2 (09:00–19:00). It is developer D4’s first week at the company, and he and D3 are tasked with implementing a new feature. D3 wants to explain the target state by showing a similar, already existing function. While D3 scrolls through the source code, D4 repeatedly interrupts him with questions unrelated to their task, and D3 always tries his best to provide all the information he can (highly compressed excerpt follows):

D3: “In principle, there should be a toolbar up here [...] I’ll show you how it looked in the old calendar. [starts navigating in the source code]”

D4: “[reading from screen] What are these navigation things for? Are these Actions? Where are they displayed?”
D3: “[stops navigating] There is a—What’s it called again? [starts searching through package tree ...]”
D4: “[later: reading from screen, chuckling] LicenseKey?”
D3: “[stops searching] You’ll see that more often around here [...] let’s see where it’s used [starts fulltext search ...]”

Since D4 is new at the company, providing him with information about the code base could be a good thing even if not pertinent to the current task. However, none of the sidetopics actually led to D4 understanding something he did not already know (not shown above), so we characterize this as a case of a pair running into trouble (as defined in Section III-C). Instead, the main topic (i.e., explaining the target state to D4) is interrupted by twelve(!) abrupt topic changes (only two of which are shown above). Finishing an exchange with a net time of 30 seconds takes the pair about ten minutes—and it could have been even worse, as D3 was nearly lost after five minutes and only found his way back because a stacktrace happened to be displayed on-screen:

D3: “OK. Now, where were we? [looks around, sees stacktrace on lower display corner] Ah, the exception, right.”

C. Anti-Pattern: Losing the Partner

Sometimes, one pair member is deeply engaged with the task at hand, trying to understand the code or developing a design idea, but does not pay much attention to her partner’s state of mind who then may or may not understand what the colleague is doing. Such behavior may be expedient in the short-term if, say, a defect is found sooner than later, but it reduces the Togetherness of the pair which may result in (a) the partner being less knowledgable later or (b) missing a learning opportunity (as discussed in [14, Sec. 6.4.3]).

Example 2: Session CA1 (19:00–21:00). Developer C1 already started implementing a new form when C2 joins. They want to make the form interactive such that one checkbox deactivates multiple input fields (called “panels” and “components” below). C2 appears to see problems with their approach but neither explains them to C1 nor react to C1’s questions:

C2: “The problem is, it doesn’t fit with getComponents [scrolls through file]”
C1: “Why doesn’t it fit?”
C2: “I think so. I could be wrong. [continues scrolling]”
C1: “We only need to get the individual component from the panel, right? Is that complicated?”
C2: “[ignoring C1] Ah, I just see it has a getContent.”
C1: “[reading from screen] A PanelBuilder. Can we possibly get the other panels from there?”
C2: “[ignoring C1, continues scrolling] I’m not sure whether this all will work.”
C1: “Can we deactivate a IPanel on its own?”
C2: “[ignoring C1, continues scrolling] OK, I’d say—Shall we simply try to implement the methods?”
C1: “Yeah, sure.”

Although the pair appears to have reached an agreement (“Shall we?”—“Yeah, sure.”), C2 has been Losing his Partner during the above two minutes; there is no way in which C1 could have properly assessed the proposal he agreed to, given that every question he asked was ignored. Similar behavior of C2 occurs multiple times in session CA1.

D. Anti-Pattern: Drowning the Partner

The opposite behavior is also a problem. Just as one pair member may provide too little explanation, she may also Drown the Partner in too many explanations that (a) go far beyond the task and are hence not expedient and (b) also threaten the pair’s Togetherness.

Example 3: Session PA3 (29:50–31:40). Developers P1 and P3 just extracted multiple occurrences of the value 0.01 that is used in several percentage calculations into a constant. P1 starts a long-winded explanation which his partner does not understand because it is built on hypotheticals and does not relate to their actual code changes. P3 gets increasingly frustrated over the course of two minutes:

P1: “It’s important to make clear that the last two ‘0.01’ have no relationship.”
P3: “Which last two?”
P1: “The last two in lines 31 and 32, for example. Assuming the two numbers would have no relation and someone who only sees the implementation with raw numbers thinks ‘Oh, there is a relation, I’ll introduce a constant’ [...]”

P3: “[later: reading from screen, chuckling] LicenseKey?”
P1: “The last two in lines 31 and 32, for example. Assuming the two numbers would have no relation and someone who only sees the implementation with raw numbers thinks ‘Oh, there is a relation, I’ll introduce a constant’ [...]”
P3: “But applied to our case this has no relevance.”
P1: “Yes, it has. Because it is a Magic Number, and Magic Number means”—P3: “But it is no longer ‘magic’. We just named it!”
P1: “I wanted to explain why we are doing this”—P3: “[annoyed] I got that.”—P1: “I only want to clarify that it’s important to”—P3: “[annoyed, staring at screen] Got it.”—P1: “make the relation with this renaming. [...] Not only to rename the variable.”
P3: “[annoyed] It’s ok.”

In general, these two developers are getting along great, but here P1 was Drowning his Partner with explanations the partner neither wanted nor needed. After the session, the two developers talked about that incident. P3 criticized P1 for providing such “unwanted lectures” too often, continuing “If I didn’t know you better, I’d perceive this behavior as arrogant”. P1 responded that some issues just need pro-active explanations, because the partner would not even know what to ask, or when. Both agreed on this and continued working productively the next day.

E. Doing the Right Thing

Good pairs maintain Togetherness and Expediency; they avoid the three negative patterns described above.

For the case of Getting Lost in the Weeds, both pair members are responsible for restraining their impulses of following new ideas right away. If good pairs get side-tracked, they notice it and work their way back together, as in the next example.

Example 4: Session JA1 (04:00–06:40). Early in the session, a simple question by J1 interrupts an explanation by J2, which leads to a misunderstanding that takes almost two minutes to clear up. To avoid Getting Lost in the Weeds, both partners explicitly switch back to the original topic (last two lines in the excerpt):

J2: “There is the central [News] plugin and multiple processors which each handle one wave. [...] It checks how the file size is changing.”
J1: “In what time window are you looking?”

 [... two minutes of misunderstanding ...]
“30 seconds, that’s what I wanted.”

“That’s 30 seconds long, the time window. Now I got you. I can show it to you [in the code] in a minute.”

“Yes. And the NewsPlugin is doing what in all of this? Does it do exactly this monitoring and the delegation to the individual wave plugins, or what?”

“No. The NewsPlugin basically only does—it gets called periodically by the cron server [...]”

In contrast to Getting Lost in the Weeds, which the partners do together, Losing or Drowning the Partner is asymmetrical: One pair member is doing something ‘wrong’ to her partner (i.e., explaining too little or too much) who should then try to avert the problem. The next two examples show how good pairs agree on which topics to address and how to limit the scope of an explanation.

**Example 5: Session DA2 (1:30:50–1:38:00),** After their somewhat chaotic start (see Example 1 in Section **V.-B.**), the session of D3 and D4 proceeds more orderly. Newly hired D4 explicitly asks his partner multiple times whether he should provide an explanation on some matter, which D3 agrees to:

D4: “Do you know about OSGi class loading?”

D3: “Class-what? Not really, no.”

D4: “Should I tell you?”

D3: “Sure.”

In both cases, the developers make sure to neither Lose nor Drown their partner.

**V. DISCUSSION**

Previous research and practitioner reports suggest that getting accustomed to working in pairs and getting familiar with a particular partner takes time. However, exhibited PP skill does not appear to directly depend on experience: We saw developers with no PP experience skillfully avoid Losing or Drowning their partner, e.g., D4 probing his partner’s knowledge gaps in the latter half of session DA2 (which was D4’s very first PP session ever), such as in Example 5; and we saw problematic behavior in developers with long PP histories, e.g., C2 (6 years of PP) Losing his Partner in session CA1, or P1 (2 years of PP) Drowning his Partner in session PA3, see Examples 2 and 3.

This leads to open questions: How do PP novices manage to have good PP sessions? Which elements of PP skill can be acquired through what types of experience? Which are specific to the context and the involved partners?

VI. SUMMARY AND FURTHER WORK

Pair programming (PP) does not just ‘work’ because two software developers sit next to each other. Rather, developers can be more or less skilled at pair programming. We characterize two elements of that skill that are independent from software development skills: Maintaining Togetherness and keeping an eye on Expediency. There are possibly more elements to be found. So far, we described three patterns of problematic behavior:

- **Getting Lost in the Weeds,** during which both partners stay together as a pair, but lose sight of which topics are worth pursuing.
- **Losing the Partner,** in which one pair member focuses too much on the task and explains too little.
- **Drowning the Partner,** in which one pair member explains too much, which may harm the pair’s Togetherness and Expediency.

Our current data is limited to snapshots of pair programmer behavior: Most pairs in the PP-ind repository [15] were recorded only once or twice during a short stretch of their pair programmer career. Nevertheless, we have already seen that prior PP experience alone does not explain beneficial and problematic behavior. Longitudinal research with the same developers over longer time frames will be needed to understand and disentangle the influence of developers’ personal styles, their day-to-day form, and their experience with pair programming in general or with a particular partner.

VII. DATA AVAILABILITY

Unfortunately, we cannot share the full audio and video material due to non-disclosure agreements with the involved companies and confidentiality agreements with the recorded developers. We do, however, provide the full original German transcripts as well as English translations for the referenced session excerpts [16].

REFERENCES

[1] E. Arisholm, H. Gallis, T. Dybå, and D. I. Sjøberg, “Evaluating pair programming with respect to system complexity and programmer expertise,” IEEE Transactions on Software Engineering, vol. 33, no. 2, pp. 65–86, 2007, issn: 0098-5589. DOI: [10.1109/TSE.2007.17]

[2] K. Beck, Extreme Programming Explained: Embrace Change. Addison-Wesley Professional, 1999.

[3] A. Belshee, “Promiscuous pairing and beginner’s mind: Embrace inexperience,” in Agile Development Conf., IEEE, 2005, pp. 125–131. DOI: [10.1109/ADC.2005.37]

[4] S. Bryant, “Double trouble: Mixing qualitative and quantitative methods in the study of extreme programmers,” in IEEE Symp. on Visual Languages and Human Centric Computing, ser. VL/HCC ’04, IEEE, 2004, pp. 55–61. DOI: [10.1109/VLHCC.2004.20]

[5] S. Bryant, P. Romero, and B. du Boulay, “Pair programming and the mysterious role of the navigator,” Int'l. J. of Human-Computer Studies, vol. 66, no. 7, pp. 519–529, 2008. DOI: [10.1016/j.ihcs.2007.03.005]

[6] J. Chong and T. Harbut, “The social dynamics of pair programming,” in Proc. 29th Intl. Conf. on Software Engineering, ser. ICSE ’07, Washington, DC, USA: IEEE Computer Society, 2007, pp. 354–363, isbn: 0-7695-2828-7. DOI: [10.1109/ICSE.2007.87]

[7] J. E. Hannay, T. Dybå, E. Arisholm, and D. I. Sjøberg, “The effectiveness of pair programming: A meta-analysis,” Information and Software Technology, vol. 51, no. 7, pp. 1110–1122, 2009. DOI: [10.1016/j.infsof.2009.02.001]
[8] L. Plonka, H. Sharp, J. van der Linden, and Y. Dittrich, “Knowledge transfer in pair programming: An in-depth analysis,” Int. J. of Human-Computer Studies, vol. 73, pp. 66–78, 2015, ISSN: 1071-5819. DOI: [10.1016/j.ijhcs.2014.09.001]

[9] A. L. Strauss and J. M. Corbin, Basics of Qualitative Research: Grounded Theory Procedures and Techniques. SAGE Publications, Inc, 1990, ISBN: 0-8039-3251-0.

[10] L. Williams, “The collaborative software process,” Ph.D. dissertation, Department of Computer Science, The University of Utah, 2000.

[11] L. Williams, R. R. Kessler, W. Cunningham, and R. Jeffries, “Strengthening the case for pair programming,” IEEE Software, vol. 17, no. 4, pp. 19–25, 2000, ISSN: 0740-7459. DOI: [10.1109/52.854064]

[12] F. Zieris and L. Prechelt, “On knowledge transfer skill in pair programming,” in Proc. 8th ACM/IEEE Intl. Symp. on Empirical Software Engineering and Measurement, ser. ESEM ’14, ACM, 2014, 11:1–11:10. DOI: [10.1145/2652524.2652529]

[13] ——, “Observations on knowledge transfer of professional software developers during pair programming,” in Proc. 38th Intl. Conf. on Software Engineering Companion, ser. ICSE ’16 (SEIP), ACM, 2016, pp. 242–250. DOI: [10.1145/2889160.2889249]

[14] ——, “Explaining pair programming session dynamics from knowledge gaps,” in Proc. 42nd Intl. Conf. on Software Engineering, ser. ICSE ’20, ACM, 2020, pp. 421–432. DOI: [10.1145/3377811.3380925]

[15] ——, PP-ind: A repository of industrial pair programming session recordings, Tech report, 2020. arXiv: 2002.03121

[16] ——, PP-ind: A repository of industrial pair programming research data, Zenodo, 2021. DOI: [10.5281/zenodo.4529143]