

Developers' Dilemma – Opportunities and Pitfalls of Generative AI for Software

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Appendix (available online via <http://link.springer.com>)

Appendix

Guiding questions for the expert interviews

Number	Question
1	Please briefly introduce yourself.
2	Are LLMs transforming existing structures within companies?
3	Are LLMs integrated into your workflow as a developer? If yes, how?
4	What potential challenges might arise for software development due to the use of LLMs, and how can they be addressed?
5	Do LLMs have an impact on the code-related productivity of software developers? If yes, what impact?
6	Do LLMs have an impact on the ability to innovate and develop new solutions? If yes, in what direction and how?
7	What conditions need to be met from a tool integration perspective for productive use?
8	Do LLMs change the diversity and number of projects?
9	Do LLMs influence the way developers work together?
10	To what extent do LLMs contribute to productivity improvement for developers with different skill levels?
11	Will the way software developers are trained and educated change?
12	Do LLMs change the perception of the value and importance of a software developer's role?
13	Will the attractiveness of the profession change? If yes, how?
14	How do you assess the impact of LLMs on the overall demand for software developers? (Macroeconomic perspective)
15	What impact do LLMs have on the working conditions of individual software developers? (Microeconomic perspective)
16	What role do you think LLMs will play in software development over the next 3 to 7 years?
17	Do you have any additional thoughts or comments on the topic or the questions posed?

Table 3: Interview questions

Exemplary quotes for the Gioia data structure

For the data structure proposed in the main text, we provide a detailed view including exemplary quotes for each aggregate dimension separately: GenAI implementation in Table 4, individual opportunities and pitfalls in Table 5 and Table 6, organizational opportunities and pitfalls in Table 7, and developers' professional identity in Table 8.

Exemplary Quotes	1st Order Concepts	2nd Order Concepts
"Clear rules need to be defined by the management in order to prevent misuse. You simply have to say: How can it be used and what must not be used." (I12, Quality manager (testing)) "I also assume that companies should generally keep such a policy internal, so that not everyone does whatever they want with these tools, but rather that this should be specified in advance [...]." (I20, Software developer) "And what is also important is that companies should ensure that the introduction of LLM tools does not conflict with existing tools." (I9) "Integration into the tool landscape must be low-threshold enough that it does not distract from the focus. This corresponds to integration into development environments, code review tooling, ticketing systems, etc." (I13, Software developer) "I think the biggest challenge at the moment is data protection and security when integrating AI into existing infrastructures." (I18, Software engineer)	Procedural system integration Technical system integration Data protection and security measures	Implementation prerequisites
"I don't think the difference lies in a developer's skill level, but in their mindset. If I see the tool as an extension of my toolbox, where I continue to critically scrutinize the answers and only use it to make everyday tasks and boilerplate code easier, then I can benefit from it regardless of my skill level." (I2) "However, it could easily be that in the future, there will simply have to be a certain level of knowledge or willingness to work with AI and not say, no, that's AI, I'm not going to touch it." (I15, Software developer) "Developers are sometimes a little reluctant to use AI because they say, yes, it's bad. What comes out of it is rubbish, and we don't need that. At least, that's very often the case in our company. And I think that sometimes developers need to rethink their attitude and realize that AI can really help them, that it can perhaps also lead to a rethink in the way they work." (I29, Requirements engineer) "it's like a baby. Right? You have to give them a clear instruction like, okay. This is wrong. This is right. And you need to do this, and you don't need to do this. Right? And this is bad. Right? And why is it bad? Sometimes you need to explain that to the LLM as well. And I guess software engineers need to understand this, needs to learn this if they want to achieve the goals that they have." (I26, Data scientist) "Depending on how LLMs develop and if you are moving in the direction of generating complete applications, you as a developer will need to learn how to enter good prompts." (I17, Senior manager) "[...] but ultimately, you still need to have an overview and be able to think conceptually about how to structure things, and then you can take the next step and use AI. I think the key is knowing when to use the tools and when it makes sense to do so." (I13, Product owner) "[...] but I think it will probably change again soon in terms of what you need to bring to the table in terms of, let's say, pure qualifications. What's really important at this point are soft skills. I think the soft skills are analytical thinking and structured working methods." (I16, Software developer) "[...] what is important is definitely creativity, which we mentioned earlier, then analytical thinking and approach, as well as an understanding of the basic functioning, so to speak, of programming language and also the system in general." (I20, Software developer) "The truthfulness must be assessed again. I should consult other sources and cross-check the information I receive." (I2, Tech consultant) "if people just use it blindly, what comes from the LLM, you, of course, might run into problems. So you have definitely to understand the code you're running and you're checking in. And if you are not able to do that because you just trust in the LLM without questioning the results, yes, then this is, of course, a risk. Like, everybody needs to be aware that that might not come up with the optimal solution, that solutions might be wrong and so on." (I28, Data scientist) "[...] in order to use this more effectively, it would definitely make sense if you could get some information or possible training opportunities" (I17) "Yes, I think prompt engineering would be a focus in education and training. The more precise the prompt, the more effectively LLMs work. You have to learn how to write a short and precise prompt instead of a long and incomplete one." (I11, Software engineer)"	Mindset shift: Acceptance of GenAI support Shifting skill requirements, especially GenAI-related skills Broad conceptual and analytical skillset Critical evaluation and responsible use Employee training programs	Success factors
"I think an LLM can certainly make a contribution to brainstorming by feeding it with a few keywords such as, this is my, my context, my situation, I would like to explore the problem space in this and every direction, so to speak." (I3, Software developer) "Co-Pilot or ChatGPT only help me in certain phases where it's really only about boilerplate code or code generation in general." (I5, Software developer) "We basically built a custom GPT for Personal Benchmark online and said, this is the current status, please create test cases for us for these scenarios." (I29, Requirements engineer) "So, it helps you to, enhance your, experience. So, like, previously, maybe you were using a different approach for dealing some, list of things in a data, but now it has suggested you some new technique, and you are readily tested it. And Yeah. That has added in your experience." (I22, Software engineer) "Yes, I also think that the error rate will probably be reduced because talking to Chat-GPT is like programming with someone else. That means you have someone else with whom you can do a kind of code review" (I4, Machine learning engineer) "But I think the way that it can help me is when I already have the idea and I kind of know the direction, and I don't know if it suggests something that maybe I haven't thought of or I don't think it would work" (I30, Frontend engineer) "There was now relatively extensive documentation online from the company itself, but reading through it all takes a lot of time, of course, so we came up with the idea of making all the links available to a custom GPT, which then accesses them via online search and provides us with the technical answers we wanted about the tool based on all the links. This meant that if we had any questions during meetings, we could quickly type them in, what is this and that?" (I29, Requirements engineer)	Creative exploration Code and documentation production Functional software testing On-demand knowledge acquisition Code review Reflection Organizational knowledge exchange	Affordances for software developers

Table 4: GenAI implementation

First-order concepts, second-order concepts, and associated quotes for the aggregate dimension of GenAI implementation.

Exemplary Quotes	1st Order Concepts	2nd Order Concepts
<i>“But if one ultimately relies solely on the machine, they will become de-skilled.” (I7, Senior manager)</i> <i>“the coding level goes down. Right? The level of coding goes down because people don’t have to solve everything from scratch anymore. Right? So that’s a danger.” (I24, Data scientist)</i> <i>“For highly skilled developers who want to venture into areas that are not necessarily part of their core competencies, the use of LLMs makes it easier and faster to acquire new knowledge.” (I11, Software engineer)</i> <i>“I feel like those who are using it in a smart way now have more potential to accelerate their career, for example, or get a promotion earlier because they just yeah. They have access to way more knowledge than they would have without chat gpt or just with Google.” (I24, Data scientist)</i> <i>“To be honest, this often reduces my stress levels, because my workload in my everyday tasks is lower when I can simply ask questions, reflect and make improvements on the side.” (I1, Software developer)</i> <i>“They will become faster and faster, deliver better and better results, and make the lives of software developers easier.” (I6, Software developer)</i> <i>“you were not sure about it before, when you’re gonna get out of this situation. But GenAI, has made this process fast. Now you at least get to know what the problem is because you are stuck. And you now you have a probability to guess how much time it’s gonna take you to get out of it” (I22, Software engineer)</i>	Becoming dependent as GenAI limits hands-on learning Support self education and training Stress relief	Personal development and well-being
<i>“So you could say that productivity, especially in things I don’t do every day, where I simply don’t have the routine, can be far more productive than I would be without the help of AI.” (I15, Team leader backend progr.)</i> <i>“Work is much more productive when LLMs are used sensibly. The simple programming tasks can be taken over by LLMs. A lot of time is saved and invested in other phases of software development.” (I11, Software engineer)</i> <i>“I believe that many things will look the same in the code, precisely because it has been completed. But I can also imagine that it will lead to cleaner code, at some point, if it is used correctly.” (I18, Software developer)</i> <i>“Maybe the quality of the code also increases as well. So, like, given that you always rework it, right, and you cut out the unnecessary things.” (I24, Data scientist)</i> <i>“Nevertheless, the code has to be validated again in any case and if you take it as it is, the code quality will be worse” (I19, Software developer)</i> <i>“The simplicity of this idea generation process and the quantity of ideas obtained could lead to many projects being initiated without really considering and planning them carefully. And that can, of course, also lead to a decline in quality.” (I2, Tech consultant)</i> <i>“[...] the code that’s generated is so complex that it will have larger run times and becomes more complex to debug, I think [these] are definitely challenges, the first ones that I would think about.” (I24, Data scientist)</i>	Productivity boost for well-defined coding tasks and documentation Improved code quality when outputs are thoroughly reviewed Lower code quality blindly accepting outputs	Individual task performance
<i>“Innovation means that you can always create something new that hasn’t been there before. And that is precisely the problem that LLMs cannot solve. As LLMs are always based on historical data.” (I7, Senior manager)</i> <i>On the other hand, I believe that excessive use of LLMs tends to stifle innovation because everyone simply accepts the whole thing. The model was trained with historical data and usually suggests the most popular or standard option.” (I10, Software developer)</i> <i>“But for in terms of innovation, as per my knowledge, I can see its assistance in enhancing the innovation you are introducing, but it cannot create an innovation for you itself.” (I22, Software engineer)</i> <i>“And I simply received a lot of suggestions for solutions. They don’t all have to be good and right straight away, but when I get a list of ten points like that, there are often two or three things that I would definitely incorporate and that I might not have thought of myself straight away.” (I4, Machine learning engineer)</i> <i>“So I think the impact on innovation or creativity is actually also positive, as you could get new logic from LLMs.” (I8, Software engineer)”</i> <i>“I think I’m more creative, at least from a different perspective, because you can say, yes, the following is the problem, and it basically gives you possible solutions, and I think I would have come up with some of them myself if I had thought about it longer, but you might not have come up with others at all, [...] and then you can think about it further because it was just a little thought-provoking impulse from the AI [...]” (I29, Requirements engineer)</i>	Lack of creative solutions and ideas from GenAI alone Foster creativity through support in idea generation	Creativity

Table 5: Individual opportunities and pitfalls (part 1)

First-order concepts, second-order concepts, and associated quotes for the aggregate dimension of individual opportunities and pitfalls.

Exemplary Quotes	1st Order Concepts	2nd Order Concepts
<i>“On the other hand, software development itself is now more accessible than it used to be, meaning that people who may have previously needed a lot of support to implement something are now asking ChatGPT say, how can I simply automate? And then you show the AI how it works. [...] In other words, the barriers to accessing technologies from the software corner are now simply much, much lower than before.” (I1, Software developer)</i> <i>“It requires less knowledge to achieve higher quality in the end product because certain things are simply outsourced to other providers. [...] I need to know less about the actual coding to produce executable code because I outsource that to the LLM.” (I3, Software developer)</i> <i>“The younger developers, they don’t understand the code, but they often deliver code which is working.” (I25, Software developer)</i> <i>“On a technical level, I think the introduction of AI such as LLMs could mean that the position of junior software developer is no longer as important, as many problems they might have could be answered by LLMs.” (I8, Software engineer)</i> <i>“I’ve noticed that it’s becoming increasingly difficult to get started because companies rarely look for juniors.” (I4, Machine learning engineer)</i> <i>“I believe that developers who are good at programming but don’t have many ideas will be less competitive because many tedious programming tasks can be taken over by LLMs.” (I10, Software developer)</i> <i>“One challenge is that software developers can be replaced by LLMs, which do not have sufficient expertise. Since LLMs can perform many programming tasks, software developers still need a great deal of expertise in code and technical knowledge.” (I11, Software engineer)</i> <i>“However, I don’t think that this will lead to more developers entering the job market. I believe that there will be a clearer distinction between who is a real developer and who is perhaps just technically savvy. I think that the job market will become more competitive, and developers will have to be more selective about which companies they work for.” (I15, Team leader backend progr.)</i> <i>“But at the same time, it’s also true that software developers are still in high demand, and it’s very difficult to find really good candidates who have not only completed, say, an eight-week online course, but who also have real experience in software development.” (I13, Product owner)</i>	Democratization of coding skills Rising competitiveness in junior developer roles Demand for senior developers increases	Labor Market

Table 6: Individual opportunities and pitfalls (part 2)

First-order concepts, second-order concepts, and associated quotes for the aggregate dimension of individual opportunities and pitfalls.

Exemplary Quotes	1st Order Concepts	2nd Order Concepts
“I believe that it is also a very powerful tool for simplifying certain communication. I also see my role as a product owner as translating technical topics to my stakeholders.” (I13, Product owner)” “Communication will not increase, but communication will be much better.” (I26, Data scientist) “It’s a kind of brainstorming, and what we do a lot in the team is share these GPTs, and I don’t think you can do that through normal communication, passing on all the knowledge they have to each individual. That means everyone in the team has the same knowledge that they can access, and you can then communicate on a different level, because I feel that everyone is more involved in the topic when you work with these GPTs. So I think it has significantly improved communication and collaboration within our team.” (I29, Requirements engineer) “The review by colleagues, human, flesh-and-blood colleagues, helps to create a kind of connection to the colleague and thus to understand each other better on some level, which promotes collaboration, even if it really is just small, trivial errors. If I have these small, trivial errors corrected with the help of AI tools in the future, collaboration will of course also suffer.” (I2, Tech consultant) “So now we see, like if you’re thinking about the mode of how data science works in a very big company. In the past, it was more like there were, like, clusters of experts. So we all knew each other. It was like a community of of experts. But now we still have the community of experts that are focused more on slightly different things. But then there is a variety of, like, standalone they were called citizen data scientists, like, five years ago” (I23, Team leader AI) “I think the initial exchange has been replaced somewhat. Above all, junior developers today try to get the first idea for a solution with the help of LLMs. The first point of contact today would be LLMs” (I10, Software developer)” “With the support of LLMs, junior software developers can usually obtain sound advice very quickly, which also saves unnecessary communication time.” (I8, Software engineer)”	More effective communication and technical discussions Increased developer independence and less frequent human interactions	Human collaboration
“In the past, for example, a team could complete three projects in two areas within two years; today, the same team can perhaps complete five projects in three areas within two years. (I9, Business analyst)” “But the number (of projects) will increase because it is now much easier to start a project. But I think there will be many projects with similar structures, but no huge diversity. (I10, Software developer)” “Yeah. Say, for example, if I can work on two projects in parallel in the past, now I can I would say I will work on three. Like, your capacity is increased because it saves your time. And the thing you are building in an hour previously, maybe you can do in twenty minutes, and then you can utilize other forty minutes for other things.” (I22, Software engineer) “A simple example: What should the documentation look like, what should the header look like, what other project specifications are there? It’s a lot of work beforehand. But depending on the size of the company, if it is trained accordingly across the company, I see a relatively big advantage, especially when it comes to, let’s say, a certain standardisation, including the processes. So I can imagine quite a lot of things that can be automated or, let’s say, taken off your hands. It’s actually the case that a lot of things in a company are usually done manually. So I can imagine quite a lot that could be automated or, let’s say, taken off your hands. The fact is, there is a lot of redundancy in companies, especially large ones, particularly in terms of how the architecture is created, how software is deployed across the entire infrastructure, and so on. These are all very similar processes, and many people simply reinvent the wheel. But if you have a common hub that centralises everything and can provide you with useful information, I see a lot of potential there.” (I16, Software developer) “In the software development, the organisational and technical structure of a project is transformed. LLMs simplify the orchestration of tasks and all processes related to how we move the code and how we deploy the code. All of this is streamlined.” (I10, Software developer) “I do think that the structure of companies has been transformed by LLMs, as there are some functions or positions in traditional corporate structures that are not so necessary. Many companies now use AI such as LLMs, and I believe they have the ability to change the corporate structure and help optimise it. Unnecessary positions could therefore be optimised, which would increase the efficiency of information transfer from top to bottom.” (I8, Software engineer) “As an enterprise, we at [company name] do have some access to features that may not yet be available to everyone. For example, there is a very interesting feature currently in the beta phase called [company name] Q&A, which basically takes all the pages that exist within the company, so to speak, that are accessible to everyone in the company. Of course, appropriate rights management is implemented, so it’s basically a Q&A. This means I can ask [company name] AI: ‘Hey, I need information about which projects the sourcing team is currently working on,’ and [company name] AI is able to find exactly this information for me from all the context, i.e. the entire workspace. I think that pretty much sums up one of the major benefits of AI, both for development and for the company in general, namely gaining knowledge.” (I15, Team leader backend progr) “So projects that are realizable that were not realizable before, I would put in the category of what can happen with an LLM towards the end user [...]” (I3, Software developer) “So many standard tasks can already be solved with an LLM like this, without having to do much extra work. And a year ago, things were still very different in some respects. [...] And I believe that many projects will increasingly revolve around LLMs. In other words, how to integrate them as efficiently as possible into company processes.” (I4, Machine learning engineer)	Increased project capacity through individual productivity gains Organizational efficiency through standardization and process streamlining Project diversity through new GenAI use cases	Organizational productivity

Table 7: Organizational opportunities and pitfalls

First-order concepts, second-order concepts, and associated quotes for the aggregate dimension of organizational opportunities and pitfalls.

Exemplary Quotes	1st Order Concepts	2nd Order Concepts
<i>“So I think that the classic profession of software developer will eventually cease to exist in its current form. I think it will become something hybrid, which will involve significantly more creative possibilities.” (I16, Software developer)</i> <i>“In seven years’ time, I believe that we could be at a point where the pure writing of code no longer takes place as we know it today. In other words, as a developer, I will no longer have to sit down and write a class myself, for example, but it will be much more of a creative process: You define contexts and more complex topics, but the writing of the actual source code can be done by artificial intelligence.” (I15, Team leader backend progr.)</i> <i>“The focus will shift in the medium term so that you are no longer a pure developer, but rather a good developer who acts as a kind of translator. I think that silly things like writing a class with this method will eventually disappear; it will be automated by LLMs. Translating human requirements so that LLMs understand everything is a big challenge. In this sense, the appreciation of such developers who build, monitor and translate LLMs will increase. The requirement to translate human language so that LLMs understand everything is a major challenge. In this sense, the value of developers who build, monitor and translate LLMs will increase.” (I10, Software developer)</i>	New professional role: from coders to hybrid roles	Shift in developers’ status position
<i>“So it could easily be that there are people who then say, no, you don’t need software developers, you do that with AI anyway.” (I5, Software developer)</i> <i>“[...] in the past, if someone is experienced, he is an important part. Maybe some companies don’t want to lose him because he knows things. He has certain certifications. Then now the probability [...] might decrease. Because you can train new people or people are adaptive to the new skills, with less effort, with less time. You don’t have to invest a lot of time to train them. [...] a mid level person can perform with smaller efforts.” (I22, Software engineer)</i> <i>“They don’t want to show that, okay, we are using GenAI tools, and it would affect our, what do you say, their images. To other developers.” (I25, Software developer)</i>	Shift in developers’ expertise monopoly	

Table 8: Developers’ Professional Identity

First-order concepts, second-order concepts, and associated quotes for the aggregate dimension of professional identity.