A Qualitative Comparison of JVM Languages from the Developer's Perspective

Lappeenranta–Lahti University of Technology LUT

Bachelor’s Programme in Software and System Engineering, Bachelor's thesis 2025

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Examiner(s): Junior Researcher Katja Karhu

ABSTRACT

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This study focuses on three representative languages in the JVM ecosystem: mature Java, modern Kotlin, and Scala, which incorporates functional programming. Unlike most quantitative studies that focus on performance benchmarks, this study takes a qualitative approach and delves into the developer experience of these languages in real-world applications through semi-structured interviews with senior developers. We find that Java's long-term stability and large ecosystem remain its core strengths; Kotlin is highly recognized for its productivity, simplicity, and safety. Scala's expressive power and flexibility make it particularly useful in specific, complex domains. The study further reveals the key factors that affect the choice of technology, including the learning curve of the language, the degree of integration with the existing tool chain, and the impact on the long-term maintainability of the project. This study provides insights based on real-world experience for development teams when choosing JVM languages, and highlights the importance of developer experience in technology evolution and decision making.

ACKNOWLEDGEMENTS

I extend my sincere gratitude to my supervisor, Junior Researcher Katja Karhu, for her invaluable guidance. Special thanks to all the interviewees who shared their insights, and to my father for facilitating key connections. Finally, I thank my family and friends for their steadfast support.This version maintains all essential acknowledgements while being significantly more concise. The language remains formal and appropriate for an academic thesis.

ABBREVIATIONS

JVM	Java Virtual Machine
IDE	Integrated Development Environment
REPL	Read-Eval-Print Loop

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Appendix 1. Raw Dataset from Questionnaire Survey

DECLARATIONS

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The originality of this thesis has been reviewed with the Turnitin similarity checking service.

AI usage

The author of this thesis, Yangyi Zhang, did not use any AI tools during the preparation of the thesis**.**

Responsibility

The author, Yangyi Zhang, takes full responsibility for the content of this thesis and has reviewed and edited the content generated by the possible use of AI tools.

1 Introduction

The evolution of the Java Virtual Machine (JVM) platform has made it develop from a single ecosystem of Java to a diversified system supporting modern languages such as Kotlin and Scala. This diversity not only improves development ability, but also makes technology selection based on comprehensive information more challenging. Currently, most comparative studies of JVM languages focus on quantitative indicators such as runtime performance, but it is difficult to evaluate their impact on key qualitative factors such as development efficiency, code maintainability, and team collaboration experience. This gap limits the depth of selection decision.

To address the above shortcomings, this study adopts a qualitative research paradigm to systematically explore the real experience of developers in the process of using Java, Kotlin and Scala. The core question is: from a developer's perspective, what are the significant perceived advantages and challenges of these mainstream JVM languages in terms of productivity, maintainability, learning cost, and toolchain support? By collecting data through semi-structured interviews and in-depth analysis using thematic analysis, this study aims to provide evidence-based insights into technology selection in practice and enrich qualitative research cases on programming language evaluation in the field of software engineering. The following sections of this paper will present the background, research methods, data analysis results and final conclusions.

2 Background

2.1 Overview of the JVM language ecosystem

Because of its stability and cross-platform ability, JVM has become the cornerstone of enterprise applications. On this platform, in addition to mature Java, modern languages such as Kotlin are rapidly gaining popularity due to their simplicity and excellent Java interoperability, especially in the mobile and backend development domains. Scala provides expressive power for building complex systems by blending object-oriented and functional paradigms, but its high learning curve is a concern. Together, these languages form a rich ecosystem of technologies with different priorities.

2.2 Limitations of existing comparative studies

The evaluation of JVM languages is mostly based on quantitative comparison, using benchmarks to measure "hard" metrics such as performance and memory efficiency. Although this kind of research is valuable, as Seaman (1999) points out, the core complexity of software engineering stems from the interaction between people and technology. Pure quantitative data cannot reveal the impact of language on "soft" factors in a real project environment, such as developer cognitive load, team communication quality, and long-term maintenance costs, which are the key basis for technical decisions.

2.3 Qualitative research methodology

Qualitative research aims to gain a deeper understanding of the "how" and "why" of social phenomena, making it ideal for exploring complex and subjective research topics such as developer experience. There are two core methods used in this study:

Semi-structured interview:

As a means of data collection, it remains flexible within the framework of a preset outline, allowing in-depth questioning to obtain rich, contextualized primary sources.

Thematic analysis method:

As a data analysis method, this study will follow the six-stage framework established by Braun and Clarke (2006) to systematically identify, analyze and report core patterns (themes) from the interview transcripts to ensure rigorous and transparent analysis process.

3 Methodology

3.1 Research Design

This study adopted an exploratory research design, used semi-structured interviews as the core data collection tool, and used thematic analysis method to systematically explain the data.

3.2 Participant selection

A purview sampling strategy was adopted to ensure that respondents all had substantial experience using Kotlin or Scala in commercial projects. Initial participants were recruited through professional networks and supplemented with snowball sampling to expand the sample. The final sample consisted of 10 software developers from different scale enterprises and business fields.

In terms of sample composition, it mainly includes two groups: one is international university students and new generation developers with multi-cultural backgrounds, and the other is professional engineers and technical managers with rich practical experience in China's software industry. This combination ensures a complementary research perspective that reflects both the acceptance of modern JVM languages by educational environments and emerging developers, as well as industry's practical concerns about technology choice for long-term projects.

3.3 Data Collection

This study was conducted in the form of one-to-one, including 5 in-depth interviews and 39 valid questionnaires, with an average duration of about 15 minutes. The research framework is constructed around three core dimensions: project experience, language feature evaluation and learning curve.

In the selection of respondents, this study pays attention to the diversity of programming background, mainly through the Internet to distribute questionnaires, covering two types of core populations: senior developers who have been employed for many years constitute the research body, providing industry practice perspective. My classmates serve as auxiliary samples, representing the new generation of developers. In order to improve the international participation and the accuracy of the responses, this survey designed a dual version of the questionnaire in Chinese and English.

In terms of data sources, the in-depth information of 5 respondents did not originate from audio recording, but directly filled in structured questionnaires with the assistance of the researchers, so as to obtain detailed answers, which were synchronously transformed into keyword text and visual charts. The remaining 39 questionnaires were also uniformly treated as structured data and view materials. After systematization, all the data together constitute the basic information base for subsequent analysis.

3.4 Data analysis

The analysis of transcripts strictly followed the six-stage process of thematic analysis of Braun and Clarke (2006) :1.Familiarize yourself with the data: Read the text repeatedly and record initial impressions.2.Initial encoding generation: Systematic annotation of textual meaning units.3.Search topic: The relevant codes are pooled to form candidate topics.4.Review the topic: Refine the topic by checking how well it matches the code and the entire dataset.5.Define and Name topics: Identify the core essence of each topic and give it an accurate name.6.Write the report: The final analysis results are presented in Chapter IV.

Data collection was conducted through questionnaires and interviews in Chinese to facilitate the participation of the target developer community. All qualitative responses were subsequently translated into English by the authors for the analysis and presentation of this paper. In the translation process, we pay special attention to preserving the original meaning and the technical context. Original Chinese responses are available upon request.

4 Literature Review

This chapter provides a brief overview of existing academic discussions related to JVM languages. It discusses their evolution, their motivation and the main differences among them. At the same time, the current situation of comparative research in this field is summarized, and the research gap that this paper aims to fill is clarified.

4.1 Overview of the JVM language ecosystem

Originally designed to run Java bytecode, the Java virtual Machine has grown into a robust cross-platform ecosystem hosting a diverse family of programming languages. While Java remains a cornerstone due to its maturity and widespread adoption, the openness of the platform has facilitated the emergence of alternative languages that aim to address some of Java's limitations or introduce new programming paradigms.

Kotlin, developed by JetBrains, is a statically typed language designed with a focus on practicality, simplicity, and full interoperability with Java. It is positioned as a more modern and secure alternative to Java, particularly through its null-safety feature and simplified syntax. JetBrains describes it as an industrial-grade language designed to boost developer productivity.

Scala (the Extensible Language) was created by Martin Odersky to combine object-oriented and functional programming into a statically typed framework. Its core design goal is to provide high-level abstraction capabilities that enable developers to write code that is both concise and expressive while remaining type-safe. This makes it particularly suitable for building complex, scalable systems.

Groovy is a dynamically typed language known for its scripting capabilities and friendly extensions to Java syntax. It injects flexibility and dynamic features into the Java platform through features such as metaprogramming, closures, and simplified collection handling.

Together, these languages form a rich ecosystem of technologies, each with different design priorities but all benefiting from the performance, portability, and vast library resources of the JVM.

4.2 Main Differences between JVM languages and Java

Syntax is one of the areas where there are significant differences. Java's syntax is known for its rigor and sometimes verbosity. Many JVM-related languages prioritize clearer and more fluent syntax. Their goal is often to allow developers to express their intentions more concisely, thus making their code more readable and expressive. Kotlin and Groovy, for example, significantly reduce verbose code through type inference, more concise function declarations, and collection literals.

In addition, Java's strict object-oriented and imperative programming model has been challenged. Scala and (to some extent) Kotlin introduce powerful functional programming constructs like immutable data, first-class functions, and pattern matching. This motivates developers to adopt a more declarative and generally less error-prone programming style. Although Java added lambda expressions in later versions, its functional support is considered to be less native and comprehensive than Scala and Kotlin.

Another factor contributing to the rise of JVM-related languages is improvements in the developer experience. These languages are often equipped with enhanced toolchains, smarter IDE support, and more interactive REPL environments. By providing a developer experience that speeds up the debugging, testing, and deployment process, these languages encourage more productive and enjoyable coding practices.

While performance is outside the scope of this paper, it is one of the driving forces behind the evolution of JVM-related languages. Although the JVM itself is highly optimized, some languages use different compilation strategies or language features to achieve better performance for certain types of workloads.

4.3 Existing research on JVM languages

The evolution of Java and its subsequent limitations have led to a variety of languages inspired by its features, syntax, and paradigms. The academic community has also reflected this trend, with a large number of papers discussing these languages published over the years.

A closer look at the existing literature reveals an interesting fact: most studies focus on a direct comparison between Java and one of its descendant languages. Such studies often examine how the emerging language compares to Java in terms of performance, ease of use, or specific features. For example, as stated by the JetBrains team when promoting Kotlin, its core advantage is "increased developer productivity by significantly reducing boilerplate code with a more concise syntax" (Breslav, 2017). Similarly, for Scala, its advocate Martin Odersky has long stated that Scala aims to "seamlessly combine functional and object-oriented programming to build scalable concurrent systems in a more elegant way" (Odersky, 2014). These studies clearly demonstrate the improvement of a single language on a particular dimension.

However, there is a lack of comprehensive comparison of various JVM languages in the current research field. Most of the existing works are "point-to-point" isolated comparisons, rather than a coherent multilingual evaluation system. For example, it is difficult to systematically know from existing literature how Kotlin's coroutines, Scala's Futures versus Akka actors, and Java's own virtual threads differ in concurrency model, resource overhead, and maintainability under microservices architecture. As software engineering scholar Smith (2022) points out in his commentary, "research on the JVM ecosystem is'

fragmented. 'We have a lot of in-depth analysis of a single technology, but lack a' big picture 'that can guide technology selection." This lack of comprehensive research makes it difficult for developers to weigh the core strengths, feature overlaps, and potential weaknesses of different languages in a broader perspective when selecting technologies for complex projects.

5 Results and Findings

This section aims to systematically present the qualitative data collected from interviews and open-ended questionnaires and the core findings distilled through thematic analysis. Through an in-depth analysis of respondents' responses, we identified five key themes that influence developers' evaluation and choice of JVM languages. To protect the privacy of respondents, all citations are presented anonymously (e.g. P1, P2,... On behalf of the survey respondents; I1, I2, ... On behalf of interview respondents).

5.1 Theme I: The overwhelming impact of ecosystem maturity and community support

Our data analysis shows that technology ecosystem maturity is the primary consideration for developers, especially senior practitioners and enterprise technology decision makers, when making technology choices.

Rich tools and libraries: Several interviewees highlighted Java's strengths in tools and libraries. One respondent (P7) clearly pointed out that Java has "a lot of encapsulated utility classes"(封装好的工具类多), which greatly improves development efficiency.

Strong community and learning resources: Community activity and accessibility to problem solving is an important sub-dimension. One interviewee (P6) said that Java was chosen because "there are a lot of users and there are many learning videos on the Internet, which can solve problems well"(使用人员比较多，网上有很多学习视频，有问题可以

很好的解决). Another respondent (P4) also mentioned "active community and rich supporting ecology"(社区活跃，配套生态丰富) as the main reason for his choice.

Reliability and ubiquity in enterprise environments: In enterprise application scenarios, stability and ubiquity of technology are critical. One interviewee (P8) pointed out that "a high general level and a mature project technology stack"(普适度高，项目技术栈成熟) are the key. Another interviewee (P17) backed this up with a historical perspective, stating that "java has been popular for so many years that it can stand the test".(java 流行了这么多年，经得起考验).

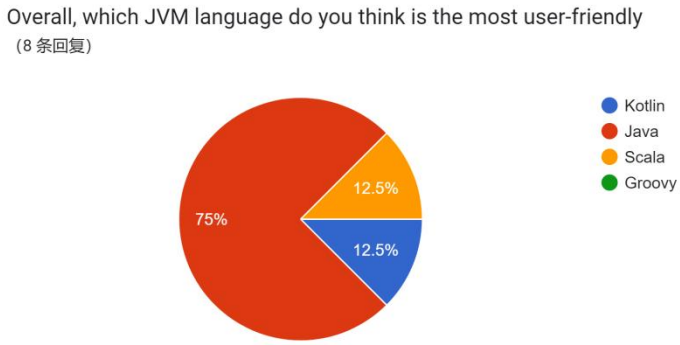

Figure 1 : Preference for JVM languages among Chinese developers

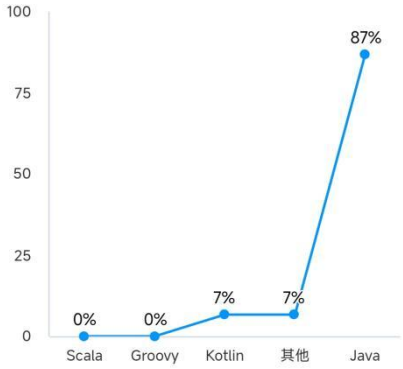

Figure 2 : Developer ratings on JVM languages among Chinese developers

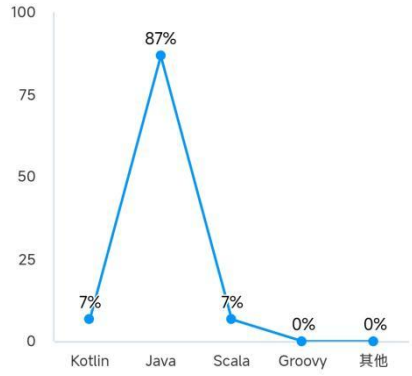

Figure 3 : Developer ratings on JVM languages among Interenational students

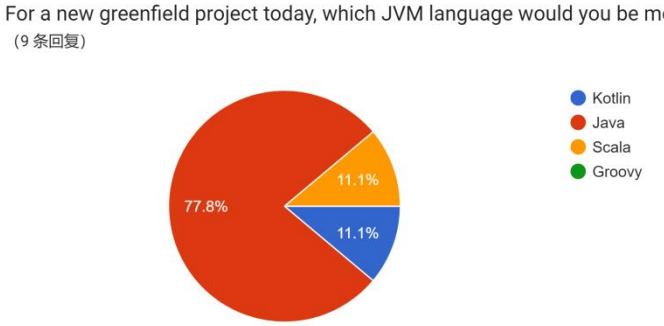

Figure 4 : Preference for JVM languages among Interenational students

5.2 Theme 2: The drive between syntactic simplicity and productivity

The simplicity and productivity of the language is a major draw for many developers, especially Kotlin speakers, who are exposed to multiple languages.

Concise syntax Reduces Cognitive Load: One respondent (I10) who preferred Kotlin directly attributed its benefits to "simple syntax, easy to learn and maintain code"(语法简单，易于学习和维护代码).

Modern language features improve expressiveness: A developer with experience in multiple languages (P19) makes a comparison in terms of paradigm support, arguing that "kotlin is better adapted to functional programming concepts. More concise "(kotlin 更好

的适应了函数编程的理念。更加简洁), which makes it more efficient in expressing complex logic.

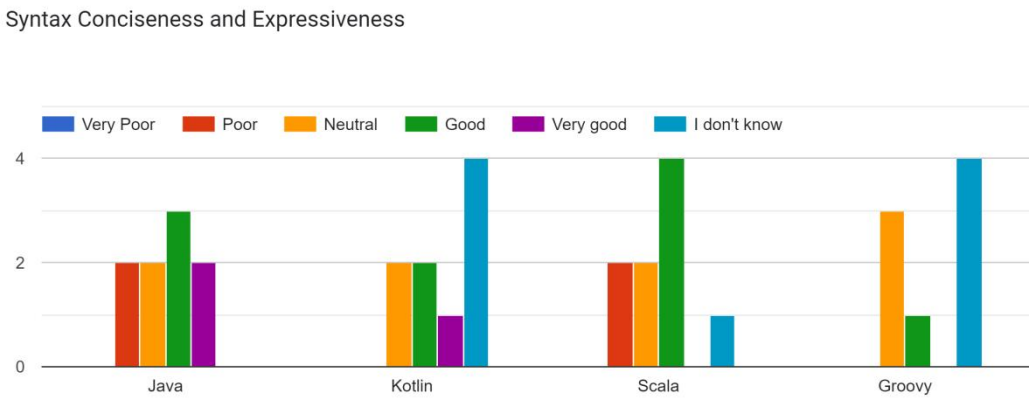

Figure 5 : Developer ratings on syntactic conciseness and expressiveness

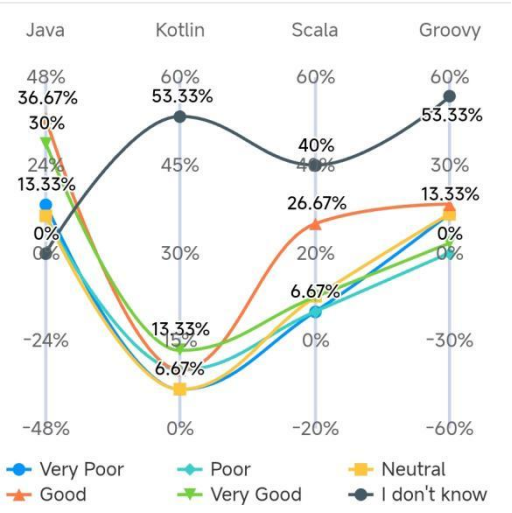

Figure 6 : Conciseness and expressiveness

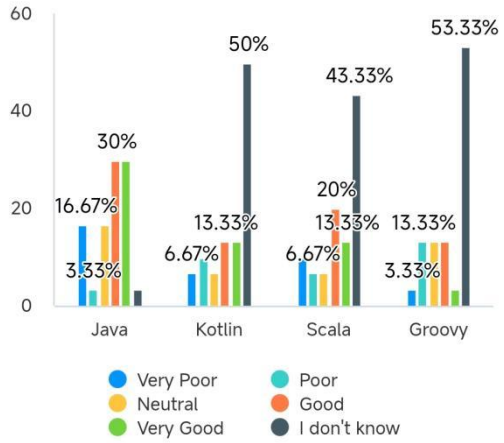

Figure 7 : Functional programming ability

5.3 Theme 3: Learning Curves and practical Considerations for Teamwork

The difficulty of language learning and its impact on team collaboration are realistic factors that cannot be ignored in organizational technical decisions.

The value of Java as a foundation skill: The position of Java in education is reflected in the opinion of one student interviewah (I4), who believes that "Java is the foundation of other JVM languages and it is easier to learn other languages after learning Java""Java 是其他 JVM 语言的基础，学会 Java 后更容易学习其他语言。”.

Team resources and Collaboration efficiency: Technology choices often override individual technology preferences. One respondent (P19) admitted that his team chose java "not for technical reasons, but for the number of developers today, and there are definitely more developers and a better community.""不是出于技术上的，在于目前开发人员的数量，无疑 java 有更多的开发人员，有更完善的社区。” Another interviewee (I1) also observed that "people tend to choose languages they are good at""人们倾向于选择自己擅长的语言。”, which leads to technology path dependency within the team.

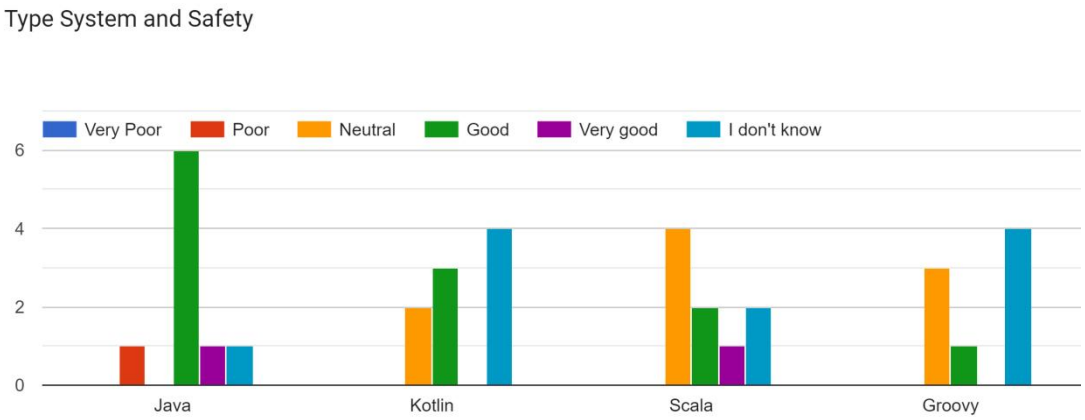

Figure 8 : Developer perceptions of type system robustness and safety features

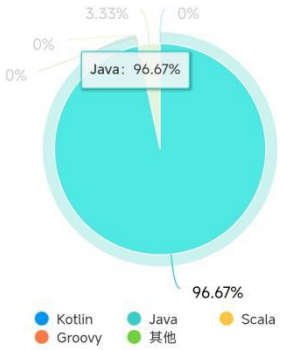

Figure 9： Developer ratings on type system robustness and safety features when selecting the "best" JVM language

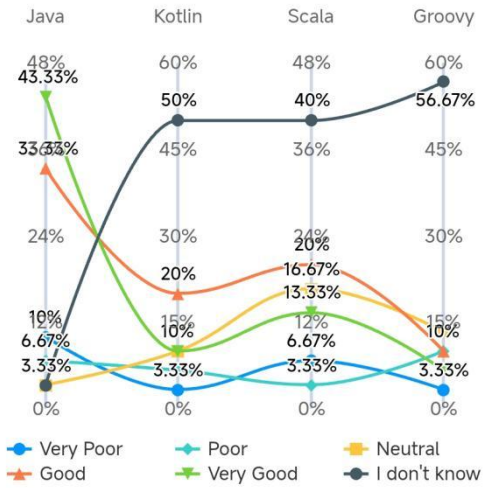

Figure 10 : Developer ratings on code readability and long-term maintainability

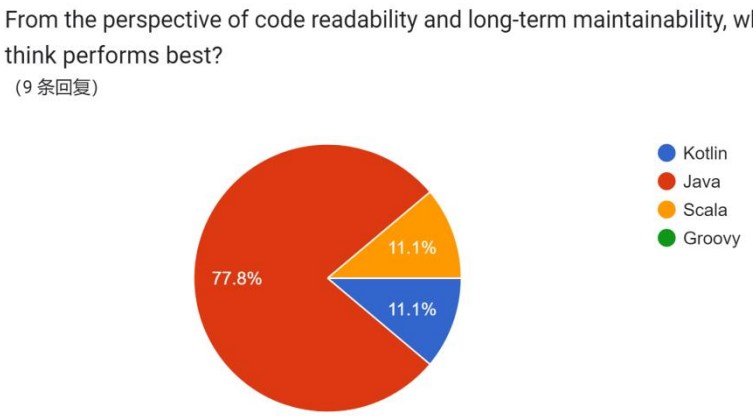

Figure 11 : Developer perceptions of code readability and long-term maintainability

5.4 Theme 4: Constraints of project requirements and technical decisions

It is found that in many cases, the choice of technology is not a free preference of developers, but is strongly constrained by specific project requirements, business scenarios and external environment.

Project requirements take precedence over personal preferences: One respondent (I4) clearly stated that "most of the time it is due to project requirements rather than by my own decision"“大多数情况是由于项目需求而不是由我自己决定。”.

Domain-specific Technical advantages: Kotlin shows its specific advantages when it comes to mobile development. One developer (I10) stated, "In mobile development, I would choose Kotlin over other languages because of its lower complexity and better performance" “在移动开发中，我会选择 Kotlin 而不是其他语言，因为它的复杂度更低且性能更好。”.

Risk aversion for enterprise projects: A technology manager (I9) explains the reasons for choosing mature technologies from a risk management perspective: "Minimizing surprises is critical; Once an accident occurs, the cost of solving it is huge.""最小化意外事件很关键；一旦发生事故，解决的代价是巨大的。” This consideration makes mature technologies such as Java more attractive for enterprise projects.

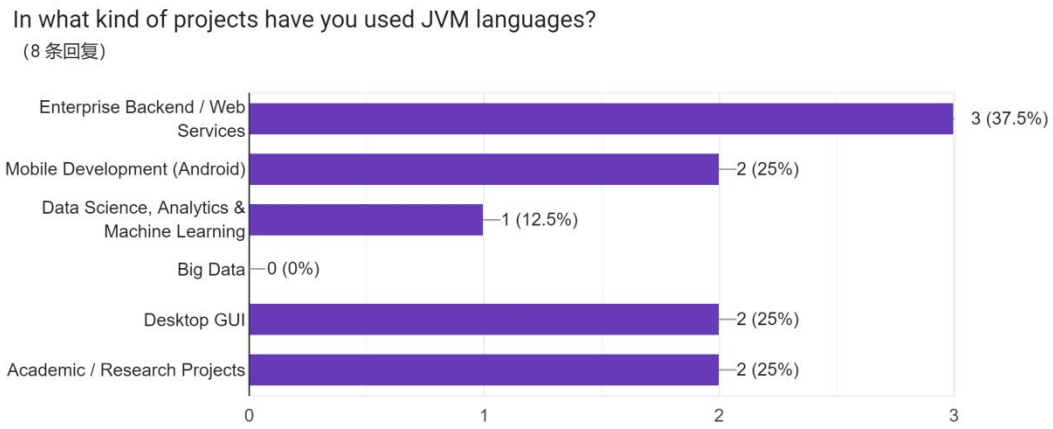

Figure 12： Project domains in which respondents used JVM languages

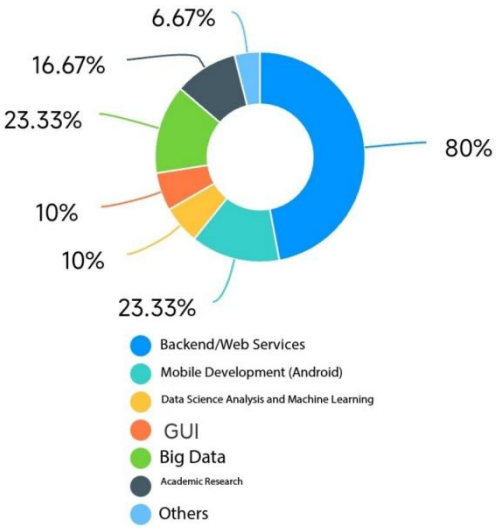

Figure 13： Distribution of project types where JVM languages were applied

5.5 Theme 5: Core values of Cross-platform capability and Long-Term maintainability

The cross-platform nature of Java (Write Once, Run Anywhere) and its reliability in maintaining long-term projects are the cornerstones of its enduring vitality.

Recognition of cross-platform value: Respondents repeatedly mentioned "cross-hardware platform" (P1) and "cross-platform" (P18) as key advantages of Java.

Long-term maintainability: One veteran practitioner (I9) summed up Java's appeal as "reliable performance, extensive ecosystem, and large developer base," “可靠性能、广泛的生态系统和庞大的开发者基础。” which all combine to ensure long-term maintainability.

6 Discussion

6.1 The Core of group Differences: Path Dependency collides with technology drive

A core finding of this study is that there is a systematic difference in the JVM language choice logic between developers from Chinese industry and students/developers from international backgrounds. The Chinese/industrial group showed a strong tendency of "path dependence" and "risk aversion". Java is the dominant choice for this group (at over 85%), driven not by a desire for cutting edge features but by pragmatic concerns about a mature ecosystem, large team resources, and long-term project stability (Seaman, 1999). In stark contrast, the international/student community shows significantly higher curiosity and acceptance of modern languages such as Kotlin and Scala while recognizing Java as mainstream. Their evaluation system focuses more on the language features themselves, such as syntactic simplicity, expressiveness, and modernization (Breslav, 2017; Odersky, 2014), is less constrained by the existing enterprise technology stack, and represents a more "technology-driven" orientation.

6.2 Interpreting key findings in context

Focusing on ecosystem maturity as a primary consideration, the key tradeoff between syntactic simplicity and the learning curve, resonates with, but improves upon, the existing technology adoption literature. While the seminal work of Meyerovich and Rabkin (2013) established that language adoption is influenced by social and economic factors rather than technical values, our study provides subtle evidence that for enterprise developers, these factors are embodied in reliance on proven community support and risk mitigation in long-term maintenance. Furthermore, experimental studies by Hanenberg (2010) demonstrate the maintainability advantages of static typing, and results from Kotlin proponents show that concise syntax combined with a robust type system leads to the most significant

productivity gains. This suggests that developer-centric design is as important as technical reliability.

The observed divergence between Chinese industry and international academia is consistent with established theories of technology diffusion. Risk-averting, path-dependent preferences in corporate Settings reflect patterns of organizational decision making documented in innovation research, while the greater openness of students and international developers to modern languages demonstrates models of technology-driven adoption typical of environments with fewer legacy constraints.

6.3 Limitations of the study

While the study provides valuable qualitative insights, some limitations should be acknowledged. The sample composition, while strategically diverse, reflects specific geographic and professional contexts that may limit direct generalization. The cross-sectional design captures perception at one point in time, while the dynamic JVM ecosystem continues to evolve rapidly. The translation of qualitative responses, while performed carefully, may affect some subtle expressions of developer experience.

Methodologically, our approach is consistent with established qualitative research standards, but the findings would benefit from complementary quantitative validation. Reliance on self-reported experience, while rich in context, introduces inherent subjectivity. Future work could address these limitations with hybrid methods and a wider range of sampling strategies.

6.4 Implications for practice and future research

For development teams and organizations, our findings suggest a structured framework for technology evaluation. Decision makers should consider four key dimensions: ecosystem maturity, development efficiency, team capabilities, and project requirements. The framework enables a more systematic selection of technologies that balances innovation with sustainability.

For the research community, this study reveals several promising directions. First, longitudinal studies that track teams through language shifts can provide dynamic insights into productivity changes and architectural evolution. Second, it would be particularly valuable to study the impact of emerging AI programming assistants on the language learning curve. Finally, extending the comparison framework to include emerging JVM technologies would help to remain relevant in this rapidly evolving environment.

These research directions will help build a more comprehensive theory of technology adoption in software engineering, while providing practical guidance for navigating the complex JVM ecosystem.

7 Conclusions

This article takes a deep dive into the JVM ecosystem, qualitatively comparing Java, Kotlin, and Scala from a developer's point of view. The study shows that the choice of JVM language is a delicate decision that takes into account not only technical performance but also key human and organizational factors.

With the research goals in mind, this study successfully mapped out the core strengths of each language: Java's unparalleled ecosystem and stability, Kotlin's enhanced productivity and security, and Scala's expressiveness for complex domains. Insights gained from developers suggest that technology choices are often a trade-off between modern language features, team proficiency, and long-term project maintainability.

As software engineering requirements continue to change, the significance of this paper is even more prominent. As projects grow in size and complexity, it becomes critical to understand the impact of language choice on developer experience. The study Bridges the gap in the existing literature by providing a cohesive, qualitative comparison that provides a valuable perspective for developers and organizations to make more informed decisions.

To summarize, while Java remains a cornerstone due to its maturity and widespread adoption, the rise of Kotlin and Scala reflects the dynamic needs of the industry. The diversity in the JVM ecosystem ensures its continued vitality, provides a range of tools for different challenges, and fosters an innovative future for software development.

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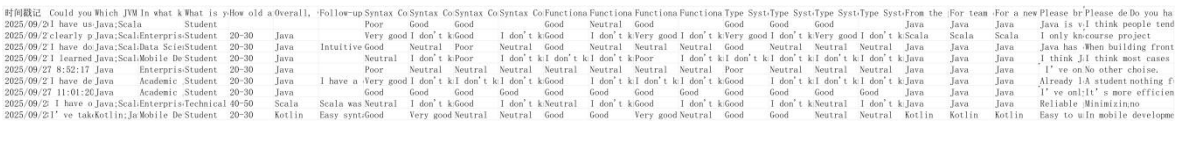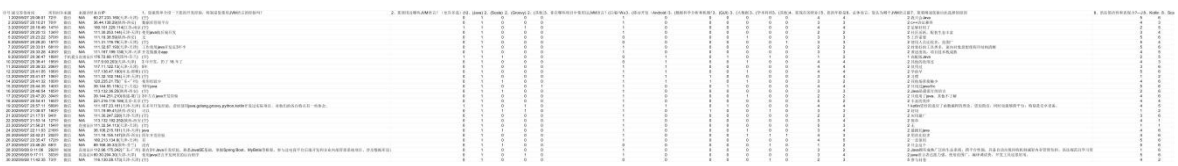
Appendix 1. Raw Dataset from Questionnaire Survey