Patterns and Best Practices of Knowledge Sharing among Programmers on Stack Overflow: A Qualitative Study

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Abstract

This research explores knowledge-sharing patterns and best practices among programmers on the Stack Overflow platform. Using a qualitative approach, the study analyzes interviews with seven programmers to identify user behavior and contributions to knowledge sharing. The findings reveal that most users exhibit passive usage, seeking solutions without actively participating due to introverted tendencies, time constraints, and concerns about redundancy and confidentiality. However, Stack Overflow remains a valuable resource for problem-solving. Best practices identified include using multiple forums, ensuring detailed and clear questions, and encouraging active participation. These strategies can enhance the quality of shared knowledge and create a more comprehensive and reliable knowledge base for the programming community. The study also suggests that addressing psychological barriers and integrating knowledge-sharing activities into routine work processes can increase active participation. These insights are essential for improving user engagement and the overall effectiveness of online knowledge-sharing platforms.

Keywords: best practice, knowledge sharing, pattern of users, programmers, stack overflow

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Introduction

Knowledge sharing is a critical process in professional communities, enabling the exchange of expertise and the accumulation of collective knowledge (Xia & Yang, 2020). Knowledge sharing is crucial for creativity, problem-solving, and maintaining a competitive edge overall, highlighting the value of cooperative learning and information sharing in a variety of settings (Mwawasi, 2022). In the digital age, online forums and communities have become vital platforms for knowledge sharing, providing spaces where individuals can ask questions, share solutions, and collaborate on complex problems. Among these platforms, Stack Overflow stands out as a leading Q&A site for programmers, boasting millions of users and a vast repository of programming knowledge. Understanding posting behavior on online platforms is a topic that has been researched by experts from different fields and traditions. When activities on online platforms are considered as knowledge sharing or the platform itself is seen as a space for learning, posting behavior is of particular interest in the tradition of computer-assisted collaborative learning (Hillman et al., 2023). From the viewpoint of complexity science, online Q&A communities are dynamic and open systems. This open system, which interacts with its environment through the exchange of matter and energy, will exhibit the characteristics of a dissipative structure under the influence of nonlinear actions (Shi et al., 2024).

Stack Overflow is a technical Q&A site where users can ask questions, provide answers, and discuss topics related to programming and software development. The site has been widely accepted by the software engineering community and has become the largest public knowledge base for programming questions. As of December 2021, there were 21.9 million questions and 32.7 million answers on Stack Overflow (Zhu et al., 2022). However, maintaining quality, relevance, and effective utilization of the answers on this site remains a challenging issue that warrants further investigation (Meldrum et al., 2020).

The question-and-answer process on Stack Overflow begins when a user posts a question related to programming or a similar technical topic. At that point, other users can get involved by submitting answers or participating in the discussion through comments or chat rooms. Discussions can be attached to the original question (called question discussions) or to the submitted answer (called answer discussions). If the answer provided resolves the question, the asking user can select that answer as the accepted answer. Once an answer is accepted, users can still contribute to the question thread by adding new answers or editing existing content, but user activity on the question tends to drop dramatically. Please note, that Stack Overflow uses the term "post" to refer to questions or answers, but not discussions (Zhu et al., 2022).

Stack Overflow provides a wealth of programming-related information in a variety of ways, making it an essential destination for software engineers to share knowledge. By helping users edit postings more effectively, Mondal et al. want to improve the quality of shared information, which will decrease the number of rejected alterations and raise user happiness (Mondal et al., 2023). Stack Overflow promotes knowledge sharing among users through various mechanisms. To increase their knowledge of programming, users commonly exchange external links; 82.5% of link-sharing activities involve external resources (Liu et al., 2022). Furthermore, commenting activities add a great deal to the knowledge acquired through crowdsourcing, as insightful remarks elevate responses from many viewpoints (Hillman et al., 2021). Additionally, the platform facilitates large-scale informal learning by enabling users to communicate and record knowledge, which produces a tension that members find both intriguing from an analytical perspective and concerning (Zhang, Wang, Chen, & Hassan, 2021).

There are studies examining the phenomenon of "obsolete answers" that continue to receive attention due to various factors, such as difficulties in editing and reevaluation (Zhang, Wang, Chen, Zou, et al., 2021). Similarly, the importance of healthy discussions for improving answer quality. Discussions related to questions offer deeper clarification and context while fostering a collaborative learning environment (Zhu et al., 2022). In "Reading Answers on Stack Overflow: Not Enough!", Zhang et al argue that simply reading answers on Stack Overflow isn't always sufficient. Their study indicates that learning effectiveness improves when users actively engage in discussions, answer evaluations, or contribute their responses (Zhang, Wang, Chen, & Hassan, 2021). Thus, understanding how platforms like Stack Overflow can foster deeper, more meaningful user participation is essential.

Understanding knowledge sharing behavior on Stack Overflow is crucial as the platform has become one of the largest sources of knowledge for the worldwide community of programmers. Stack Overflow serves as a collective knowledge hub where programmers from different backgrounds contribute to solving complex problems. Some of the reasons that underlie the importance of this research include:

1. The Ultimate Source of Information for the Programming Community.

   Stack Overflow has millions of users and is the primary source for programmers to get solutions to technical problems. There are 21.9 million questions and 32.7 million answers on this platform (Zhu et al., 2022). Given its scale and impact, understanding how knowledge sharing behavior occurs on this platform is highly relevant as it will affect the quality of knowledge accessed by millions of users.

2. Quality of Knowledge Shared.

   Inactive or passive knowledge sharing behavior can reduce the potential benefits to be gained from platforms such as Stack Overflow. Hillman et al (2023) mentioned that active participation is essential to ensure rich discussions and deeper knowledge. This study highlights the importance of addressing the issue of passive participation to improve the quality of knowledge available. While Stack Overflow has become a major platform for knowledge sharing among programmers, a pattern that often emerges is the passive use by most of its users. Many users prefer to search for solutions without actively contributing to the discussion or providing answers. This passive usage pattern has serious implications for the quality of knowledge shared, as well as reducing the potential collaborative learning benefits that can be gained. Therefore, it is important to study the factors that drive passive usage and develop strategies to increase active participation.

3. Impact on Innovation and Technology Development.

   This research contributes to improving the quality of knowledge sharing on digital platforms that ultimately supports innovation in the technology industry. Kim (2021) stated that effective knowledge sharing can improve innovation performance in organizations. By better understanding the factors that influence sharing behavior on Stack Overflow, we can identify ways to improve collaboration and innovation in the software industry.

4. The Role of Digital Platforms in Collaborative Learning.

   Stack Overflow is not just a Q&A forum, it is also a globally recognized collaborative learning space. According to research by Mwawasi (2022), digital platforms like Stack Overflow play an important role in promoting informal and collaborative learning. By studying the sharing behavior on these platforms, this research can help improve learning methods in the wider community of programmers.

5. Opportunities to Increase Active Participation.

   This research not only aims to describe sharing behavior, but also offers practical recommendations that can increase user engagement on Stack Overflow. By addressing psychological and social barriers, as well as improving platform features, active user participation can increase, which in turn enriches the knowledge base and quality of discussions in this community.

For these reasons, this research is important to study because its contribution is not only academic, but also has an impact on real practices in software development and collaboration around the world. This study aims to find answers to the research questions, namely: (1) What is the pattern of users in doing knowledge sharing on the Stack Overflow site? (2) What is the best practice in doing knowledge sharing on the Stack Overflow site?

This study looks at how various user types participate in knowledge sharing on Stack Overflow with an emphasis on user behavior and contribution patterns. This research makes a significant contribution to understanding knowledge-sharing patterns and best practices among programmers on the Stack Overflow platform. Through a qualitative approach and in-depth interviews with seven programmers,

this research uncovers the dominant use of passivity on Stack Overflow, as well as identifies key factors such as programmers' introverted nature, time constraints, and the belief that most problems have been solved before. The research also provides practical insights into best practices in effective knowledge sharing, such as using multiple forums, ensuring clear and detailed questions, and encouraging active participation. These findings are valuable for improving user engagement and the quality of knowledge shared on Stack Overflow and similar platforms. In addition, this study also recommends further areas of exploration, including psychological and social factors that influence active participation, thus providing a comprehensive basis for future research in this area.

The novelty of this research lies in the in-depth examination of Stack Overflow's passive usage patterns and the identification of specific best practices to improve knowledge sharing among programmers. In contrast to previous research that has focused more on the general benefits and challenges of online forums, this study examines programmers' behaviors and attitudes in detail, providing a detailed analysis of their interactions with the platform. Previous research such as Prescott et al (2019) have examined the general benefits and challenges of online forums, such as user participation in mental health forums. Prescott highlighted the challenges of maintaining safety and user expectations. The emphasis on programmers' introverted nature as an important factor influencing their level of participation offers a unique perspective that has not been widely explored in the existing literature. In addition, the qualitative approach used in this research, involving in-person interviews and thematic analysis, adds depth to the understanding of user behavior on Stack Overflow, differentiating it from more quantitative or survey-based research. This research not only enriches the academic discourse on online knowledge-sharing communities but also provides practical recommendations that can be implemented to improve user engagement and the overall effectiveness of these platforms.

Literature Review

Knowledge Sharing

Knowledge sharing has now become an important element in organisations (Halisah et al., 2020), because effective strategies in knowledge sharing have the ability to improve innovation performance (Scuotto et al., 2020). Recent research emphasises the importance of collaborative knowledge translation practices in supporting the internationalisation of research and development teams and the improvement of innovation quality (Serino et al., 2020). Knowledge sharing is key for organisations that want to exist in a highly competitive and dynamic environment. Experts have identified that knowledge sharing contributes significantly to innovation and improved performance (Kim, 2021).

Among academics and practitioners, continuous knowledge sharing has been recognised as a beneficial behaviour. In recent years, rapid advances in information technology have made the Internet a major platform for information exchange (Nie et al., 2024). The way we share knowledge has changed significantly from physical environments to digital platforms, with online media being the main evidence of this shift (Yoshikawa et al., 2023). Disseminating information via the Internet is now a common activity, where individuals can safely and efficiently provide answers to questions or share items of interest (Nguyen et al., 2019). This not only strengthens interpersonal trust, but also contributes to increased well-being and individual contentment (Nie et al., 2024).

However, given the privacy offered by the Internet, people who share information online may be driven by different motivations and obtain outcomes that are not the same as those who share information offline (Nguyen & Fry, 2022). In the online world, the influence of managerial and organisational factors is smaller, while individual factors become more dominant. As a result, online sharing behaviour is more related to meeting the internal needs of each individual (Kumi & Sabherwal, 2019).

They expect the satisfaction derived from helping others through online platforms (Nguyen & Malik, 2022), and improve their reputation by contributing knowledge (Shehab et al., 2023). They can receive more feedback and comments on their uploaded content or answers. This online sharing process significantly contributes to their improved well-being and self-confidence (Zheng et al., 2023). Unlike offline knowledge sharing which is private, social media allows transparency in all interactive

information. Users can observe how others behave and respond. Interacting with strangers positively on these platforms can also help fulfil their social needs (Kang, 2020).

Stack Overflow

Stack Overflow (SO) as a technical Q&A site has become an important centre for software developers to exchange information and support their community. Despite SO's popularity and success, understanding and finding information on it remains a big challenge (Nadi & Treude, 2019). To ensure posts are easy to understand, Stack Overflow allows users to use Markdown and HTML in editing. This allows them to apply various formats such as bold, italicised, and coded text, so they can highlight important parts and draw other users' attention to crucial information in the post (Ahmed et al., 2024).

A review of software engineering literature revealed that Stack Overflow is highly effective in deepening users' understanding of various software engineering topics (Haque et al., 2020). As one of the largest and most popular online Q&A forums, Stack Overflow provides a platform for developers to get answers from fellow professionals and also answer other people's questions, thus enriching their knowledge in the field (Silva et al., 2021).

To help developers craft high-quality questions, Stack Overflow has provided its community with in-depth quality assurance guidelines. However, many questions submitted do not meet the platform's quality standards. These questions are often vague, inaccurate, or do not provide adequate solutions, making it difficult for experts to provide appropriate answers.

As a result, knowledge sharing and progress within the SO community is hindered (Yang et al., 2024). One of the reasons for the low quality of questions is the inability of users to create informative titles. This could be due to their lack of familiarity with related knowledge and terms, or their poor writing skills (Gao et al., 2020).

Qualitative

A qualitative approach is a method used to understand social phenomena from the perspective of the people who experience them (Creswell & Creswell, 2018). This approach focuses on an in-depth exploration of the experiences, perceptions, and behaviors of individuals in a particular social context, which cannot be explained with quantitative data. Therefore, in this study, a qualitative approach was used to deeply explore the patterns of knowledge sharing behavior at Stack Overflow. The Focus Group Discussion (FGD) method was used in this study to facilitate interactive discussions between participants, all of whom were programmers with experience using Stack Overflow. FGDs allow participants to share their experiences and perspectives, as well as bring up ideas that may not come up in individual interviews. This method is very effective in exploring the factors that influence passive and active knowledge sharing behaviors on online platforms (Schulze et al., 2022). After the data was collected through FGDs, the Thematic Analysis method was used to analyze the data. Thematic Analysis is a technique that allows researchers to identify recurring patterns in the data and organize them into themes relevant to the research question (Kiger & Varpio, 2020). In this study, Thematic Analysis was used to find the main themes related to passive and active knowledge sharing behaviors on Stack Overflow, as well as the factors that influence them. Using FGDs and Thematic Analysis, this research was able to reveal the psychological, social, and practical factors that influence knowledge sharing patterns on Stack Overflow. This approach provides a richer and deeper understanding of how and why users tend to be passive or active in knowledge sharing.

Qualitative research encompasses a variety of approaches that produce findings without relying on quantitative measurements or statistical analyses. These methods often involve personal interviews, group discussions, participant observation, ethnography, and several others. Traditionally, qualitative research has been used in a variety of fields to describe specific phenomena. For example, in early cultural anthropology, participant observation was used to record the beliefs and practices of specific cultural groups (Hamilton & Finley, 2020).

Qualitative research is ideal for addressing uncertainty and limited predictability in socioeconomic interactions and understanding the specific context of economic phenomena. It emphasises an in-depth

understanding of the complex interactions of various factors that shape social phenomena and structures. This is particularly important in polycrisis situations, where it is important to understand both the crisis event and the underlying structure. Qualitative methods also allow for open and flexible analyses of new phenomena and contexts (Porak & Reinke, 2024).

The qualitative research approach assumes that the phenomenon under study is influenced by context, evolving, and open to multiple interpretations. These factors cannot be simplified into independent variables and cannot be investigated with controlled scientific precision. Qualitative methods bring researchers closer to participants, rejecting the idea that researchers are completely independent and objective observers. Instead, researchers must consider the influence of their presence through reflexivity. This approach, which also involves broader social theories, highlights social and ethical issues in robotics research. It encourages researchers to take a more critical stance towards issues within the field (Veling & McGinn, 2021).

This study required a qualitative method as it aimed to gain an in-depth understanding of knowledge sharing patterns and best practices among programmers on Stack Overflow. Through in-depth interviews, the researcher was able to uncover the reasons behind passive use and factors such as introverted tendencies, time constraints, and concerns about confidentiality. Qualitative methods also allowed for more detailed contextual analyses, identification of psychological and social barriers, and the discovery of practical strategies to improve the quality of questions and active participation. This approach encourages reflexivity and flexibility, allowing researchers to adjust the focus according to evolving findings and providing comprehensive insights into knowledge sharing behaviour on digital platforms.

Methodology

This research adopts a qualitative approach to explore the use of Stack Overflow in the programmer community. Qualitative research is an approach to exploring and understanding the meaning individuals or groups ascribe to a social or human problem. Emerging questions and methods, data acquired in the participant's environment, inductive data analysis that builds from specifics to broad themes, and the researcher's interpretations of the data's significance are all part of this research process (Creswell & Creswell, 2018). This approach was chosen for its ability to provide an in-depth and contextualized understanding of social phenomena regarding programmers' perspectives on using Stack Overflow as a knowledge-sharing media.

Research Approaches

In the qualitative analysis, we conducted a manual study to get user patterns in sharing knowledge on the Stack Overflow website, then we will make clusters according to the similarity of user behavior. In addition, based on the results of interviews that we conducted with several respondents, we will conduct an in-depth analysis so that we can get best practices in sharing knowledge on the Stack Overflow website. The term 'manual study' in the context of this research refers to the process of data collection and analysis that was conducted manually by the researcher, without the use of automated data analysis software. All data from the Focus Group Discussions (FGDs) were organized and analyzed directly using traditional methods, such as in-depth reading of transcripts, identifying emerging themes, and manual coding using Microsoft Word and Excel. The manual approach was chosen in this study due to the relatively small number of respondents, as well as the need to conduct a more flexible and in-depth analysis of the respondents' behavior patterns (Hillman et al., 2023). With a manual approach, the researcher can get closer to the data and be more responsive to nuances and details that automated software might miss. While data analysis software such as NVivo can help analyze qualitative data, the manual approach still provides advantages in flexibility of analysis, especially for small samples and for research that requires more in-depth interpretation.

Target Respondents

The target respondents in this study are programmers who either actively or inactively use Stack Overflow in their daily lives. This research focuses on their experiences and perceptions regarding the use of the Stack Overflow website in knowledge sharing to ensure that the data collected covers a wide

range of user perspectives. This selection of respondents aims to gain a comprehensive picture of the acceptance and influence of the Stack Overflow website in users' daily lives in sharing knowledge about the world of programming. All respondents interviewed in this study are domiciled in Indonesia. The selection of respondents from one country was done to ensure cultural homogeneity and work context in identifying knowledge sharing patterns at Stack Overflow.

Research Stages and Flow

The research process consists of several important steps, starting with a clear and defined problem formulation. After that, a literature review was conducted to build a strong theoretical basis and construct the research model. The data collection stage involved direct interaction with respondents, followed by rigorous and structured data analysis. The research ended with the formulation of logical conclusions and practical suggestions. The research began with a clear identification of the problem and a literature review to gain an in-depth understanding of the topic. A framework was then created to guide data collection. Data collection was conducted through semi-structured interviews using the Microsoft Teams virtual platform. Once the data was collected, analyses and calculations were conducted to develop valuable conclusions and recommendations.

Data Collection

At the data collection stage, interviews were conducted with seven respondents who all work as programmers. This study only involved seven respondents because the results obtained were sufficient to answer the research questions, providing important insights into knowledge sharing on the Stack Overflow forum by programmers. Data collection took place from 16 to 17 May 2024, using the Focus Group Discussion (FGD) method. FGD involves collecting data through group interactions on a topic determined by the researcher (Creswell & Creswell, 2018). FGD is used because FGD can encourage participants who are reluctant to be interviewed alone, and also encourage participants who feel they have nothing to say (Kulkarni & Dandekar, 2021). This method is very suitable for use with programmer respondents, who are known to be quiet and rarely talk. This study used a purposive sampling method with the criteria that respondents must have worked or are currently working as programmers, participating in the development of applications, websites, or software systems, especially in the coding stage. The similarity of these roles allows researchers to obtain more focused information about programmers' perceptions of the Stack Overflow forum in sharing knowledge. The diversity of each participant's industry sector allows this study to have a broader understanding of their background, regulations, and company culture. The profiles of the participants are presented in Table 1.

The FGDs were conducted online to overcome logistical challenges arising from the geographical limitations of the respondents (Shaheen & Ibrahim, 2022), who came from different cities and different industries. In addition, this choice was also driven by the time constraints and flexibility of the respondents (Stewart et al., 2022), who often have busy work schedules. By using a virtual platform such as Microsoft Teams, we can ensure that all respondents can participate without having to physically travel, which may be difficult to schedule. However, online FGDs also have some limitations. One of them is the lack of non-verbal observations that are often more obvious in face-to-face FGDs (Daniels et al., 2019). Non-verbal signs such as body language or facial expressions may not be optimally visible on an online platform. Also, social interactions that are usually more dynamic in face-to-face sessions may become a bit limited in the online format (Daniels et al., 2019). Technical glitches such as an unstable internet connection can also affect the course of the discussion (Halliday et al., 2021). To overcome these limitations, we made sure that each participant was familiar with the platform before the FGD started, and provided technical guidance if needed. We also facilitated more personalized interactions by asking each participant to actively contribute and allowing sufficient time for each respondent to speak without rushing. In addition, the recording session also helped in capturing audio details that may have been missed during the session, allowing for a thorough analysis. While online FGDs have some limitations, the steps taken to mitigate these challenges ensure that the data collection process continues to work well and yield deep insights. Therefore, online FGDs were a suitable and effective option for this study, considering the logistical limitations and the needs of the respondents.

Table 1. Profile of the Interview Participants

No.	Role	Educational Background	Work Experience (years)	Industry Sector	Domicile
1	Application Operation Support	Bachelor of Informatics Engineering	2+	Government and Information Technology	Jakarta, Indonesia
2	Application Operation Support	Bachelor of Computer Science	2+	Government and Information Technology	Jakarta, Indonesia
3	Application Operation Support	Bachelor of Informatics Engineering	2+	Government and Information Technology	Jakarta, Indonesia
4	Ex-Freelancer Fullstack Developer	Bachelor of Informatics Engineering	5	Information Technology	Depok, Indonesia
5	iOS Developer	Bachelor of Computer Science	3	Information Technology	Depok, Indonesia
6	Ex-Automation System Engineer	Bachelor of Electrical Engineering	8	Manufacturing and Automation Technology	Depok, Indonesia
7	The first Researcher of Remote Sensing Data	Bachelor of Physics	5	Government and Information Technology	Depok, Indonesia

In qualitative research, as explained by Creswell & Creswell (2018), sample size is not determined by the number of participants but rather by the achievement of data saturation, which is when no new information or themes emerge from additional interviews. In this study, seven respondents were considered sufficient because at that point, key patterns related to knowledge sharing behavior on Stack Overflow had emerged consistently, and additional interviews did not provide new insights. According to Braun & Clarke (2021), data saturation is often achieved with a relatively small number of respondents, usually between 6 to 12 people, depending on the complexity of the phenomenon under study. In this study, seven respondents were sufficient to achieve data saturation, as additional interviews no longer provided new themes related to knowledge sharing behavior on Stack Overflow. This research uses a qualitative exploratory approach that focuses on an in-depth understanding of respondents' experiences and behaviors. In a qualitative context, the number of respondents does not have to be large, as the purpose of the research is to explore deep understanding, not to make generalizations. Therefore, the seven respondents selected were sufficient to provide rich and deep insights into the usage patterns of Stack Overflow. Although only seven respondents were involved, this sample was chosen with diversity in mind, in terms of industry, role, and experience in using Stack Overflow. This ensures that a variety of relevant perspectives can be accommodated in the analysis, so that the research results include a more comprehensive picture of knowledge sharing behavior on this platform.

In this study, all respondents gave their informed consent prior to participation. Before the FGD session began, the researcher explained the purpose of the study, the methods used, and how their data would be managed and protected. The respondents were given the opportunity to ask questions and understand the implications of their participation in the study before agreeing to be involved. As the study was

conducted virtually through the Microsoft Teams platform, consent was obtained verbally and recorded as part of the FGD session. Each respondent clearly expressed their willingness to participate after hearing an explanation of the study and their rights as a participant. All consent recordings were securely stored in accordance with research data storage procedures. The study was conducted in compliance with the principles of research ethics set out by the university and relevant research institutions. Respondents were informed that their participation was voluntary, their data would be kept confidential, and they could withdraw from the study at any time without consequences. In addition, respondents' real names were not used to maintain their confidentiality.

The interview was divided into four parts as shown in Table 2. The first part includes background information on the respondents, including programming projects they have worked on or are currently working on. The second parts focus on questions about the coding process, delving into the problems that respondents often face when working on application development projects, as well as how they solve them. The third parts ensures that respondents are actively sharing knowledge in their field. The fourth parts examined the respondents' interaction in sharing knowledge through discussion forums between programmers on the internet, such as Stack Overflow or other platforms, and their reasons for using these platforms. In this section, the information obtained reveals the respondents' behavior and views on the effectiveness of these discussion forums, in formulating best practices for all members in sharing knowledge.

Table 2. Interview Questions List

Interview Sections	**Questions**	**Caption**
Background Information	What is your role or title at your current workplace?	-
	How long have you been working at your current workplace?	
	What is your educational background?	
	Can you mention your work history before your current workplace?	
	How long have you been working as a programmer?	
	What programming languages are you proficient in?	
	In your opinion, what is your level of proficiency in programming?	
	How many applications/websites/programs have you developed, either by yourself or with a team?	
	Can you tell us about the development process of one of the applications/websites/programs that you have worked on or are currently working on?	
Coding Process	Have you ever experienced problems in developing an application/website/program, especially in the coding section?	This interview question is to answer the first research question
	What do you usually do if you experience problems with the code you write?	
Knowledge Sharing	As a programmer, do you often share knowledge of the latest knowledge in the field of programming languages, such as informing the latest updates, or sharing fix codes with colleagues?	
	How do you see the role of a programmer in developing and spreading knowledge in the field of programming?	
	What do you think programmers can do to develop new knowledge in the field of programming?	

Interview Sections	**Questions**	**Caption**
Personal Inquiries	Have you ever used knowledge-sharing forums dedicated to programmers? For example, like Stack Overflow, or other forums. - If "YES", how was your experience when using them? - If "YES", are there any features you would like that are not available on these forums? - If "NO", why don't you use these forums?	
	What do you do in the forum?	
	How important do you think the Stack Overflow website is for knowledge sharing?	This interview question is to answer the second research question
	What do you think is the most effective way to share knowledge on the Stack Overflow website?	

This FGD was divided into two sessions and was conducted online using the Microsoft Teams platform, and the sessions were recorded using the same platform. The first FGD was conducted with P1, P2, and P3, and the other was conducted with P4, P5, P6, and P7 as respondents. These FGDs are designed with open-ended questions to ensure the answers from respondents are not limited to a set of defined answers. The authors determined the seven respondents based on several reasons that support the purpose of the study, namely to gain comprehensive insights into knowledge sharing patterns among programmers at Stack Overflow. The following are the justification sentences for the selection of the seven respondents:

1. **Diversity of Professional Backgrounds:** The respondents were selected because they come from various industry sectors, including information technology, government, manufacturing, and automation. This diversity allows the research to cover a wide range of perspectives and knowledge sharing practices that may differ between sectors.
2. **Relevant Work Experience:** Each respondent has significant work experience in programming, with the duration varying from 2 to 8 years. This experience ensures that they have sufficient depth of understanding and practice in knowledge sharing in online communities.
3. **Adequate Education Level:** All respondents have a strong educational background in informatics engineering, computer science, or electrical engineering. This adequate education ensures that they have a strong theoretical and practical basis for participating in knowledge sharing discussions.
4. **Diverse Roles and Responsibilities:** Respondents have various roles such as Application Operation Support, Fullstack Developer, iOS Developer, and System Engineer. This diversity of roles helped the researcher to understand the knowledge sharing patterns from different job perspectives.
5. **Experience Using Stack Overflow:** Respondents were selected because they had both active and passive experience in using Stack Overflow as a knowledge sharing platform. This is important to identify usage patterns and best practices in knowledge sharing on the platform.
6. **Appropriate Data Collection Methods:** The selection of respondents was also based on their availability to participate in Focus Group Discussions (FGDs) and semi-structured interviews, which are the data collection methods used in this study. This ensures the data collected is relevant and in-depth.
7. **Focus on Practical Experience:** Respondents were selected based on their ability to provide practical insights into the app development process and programming troubleshooting. This supports the research objective of identifying best practices in knowledge sharing on Stack Overflow.

These criteria aim to ensure that each respondent has sufficient experience to provide rich and relevant insights into knowledge sharing patterns on Stack Overflow. The respondent recruitment procedure was

conducted through a purposive sampling approach, where the researcher intentionally selected individuals who fit the inclusion criteria (Campbell et al., 2020). Respondents were contacted through professional networks and communities of programmers on platforms such as technology-related online discussion groups. The research invitation was sent via email, explaining the purpose of the research, the procedure, and their rights and obligations as participants. After receiving responses from interested potential respondents, the researcher conducted further verification to ensure that they met the predetermined inclusion criteria. This verification was done through an initial communication session, where the researcher ensured that each respondent had experience using Stack Overflow and was in a relevant industry. Only respondents who met all the criteria were invited to participate in the FGDs.

In formulating the interview questions, we followed an approach that focused on the research objective, which was to explore knowledge sharing patterns at Stack Overflow. The process of formulating these questions did not require an in-depth theoretical foundation, as the main focus was on ensuring that each question was able to help answer the research questions that had been set. The interview questions were structured to explore respondents' experiences, behaviors, and views regarding the use of Stack Overflow. The main focus is on the relevance of data that can support the answers to the research questions, so the questions are more directed at the respondents' real practices and experiences, without necessarily involving certain theories. In a qualitative approach, flexibility is key (Olsen, 2019). Therefore, the interview questions were structured to remain open-ended, allowing respondents to provide in-depth and exploratory answers. We focused on constructing questions that could directly provoke rich discussions, without requiring references from journals or rigid theories. With this approach, we ensured that the interview questions could elicit deep and relevant insights to answer the research questions, without the need to refer to specific theories or journals. This approach is consistent with the qualitative methods we studied, which emphasize flexibility and relevance to the research objectives.

The FGDs were conducted through the Microsoft Teams platform and moderated directly by the researcher. The discussion lasted about 60 to 75 minutes, with pre-prepared main topics related to knowledge sharing patterns on Stack Overflow. The moderator played a role in guiding the discussion, ensuring each respondent participated, and keeping the discussion focused on the research objectives. During the FGD, the moderator ensured that each respondent got a chance to speak and answer questions. We used a round-robin approach, where each respondent was given time to express their opinions in turn. If any respondents seemed passive, the moderator directly asked them questions to encourage active participation. In this way, each respondent had a fair chance to contribute to the discussion. The main purpose of this FGD was not solely to reach a consensus, but rather to explore the diverse views and experiences of respondents regarding knowledge sharing behavior on Stack Overflow. However, in some topics, such as technical barriers faced by users when sharing knowledge, respondents reached an agreement that concerns about the confidentiality of personal information is one of the main factors that hinder active participation. The FGD process went well, with each respondent having the opportunity to contribute, and a variety of views were uncovered. Although consensus was not always achieved, the research objective of exploring diverse perspectives and experiences was well met.

Data Analysis

In this study, data analysis was conducted using the thematic analysis method. This technique is used to evaluate qualitative data by looking for recurring patterns in the data set and reporting the results. Thematic analysis is a method for understanding data by using interpretation during the process of code selection and theme generation (Kiger & Varpio, 2020).

The steps of thematic analysis in this study consisted of six stages (Kiger & Varpio, 2020). In the first stage, researchers transcribed the audio interviews that had previously been conducted, helping them to make sense of all the data collected. Additionally, in this stage, the data was translated into English as the interviews were initially conducted in Indonesian. The second step involved initial coding, with codes being created to facilitate grouping and organizing the data. In the third stage, the search for themes was conducted by re-evaluating the data that had been grouped by code, to find potential themes. In the fourth step, the discovered themes were reviewed for congruence with the underlying codes. In

the fifth step, the themes were named and aligned with the research questions. Finally, in the sixth step, the results of the thematic analysis were presented in sentence form. The whole process of thematic analysis was done manually with the help of Microsoft Word and Microsoft Excel and involved researcher interpretation.

Results

This section presents the data collected, the data analysis process, and the findings of this research, by the methodological steps previously described, and incorporates the theories discussed in the literature review chapter.

Theme 1 – Usage Pattern in Stack Overflow

Passive Usage

Across both Focus Group Discussions (FGDs), it was observed that the questions respondents wanted to ask were often already available or had already been asked by another user. Consequently, the respondents did not feel it necessary to pose questions that were already present. This redundancy reduced the inclination to create new threads, as participants preferred to refer to existing discussions rather than initiate repetitive inquiries.

"For me, I usually read the existing ones first. But if there is something specific and there is no solution, then I try to ask." - *P6*

"I can answer up to 70% from Stack Overflow." - *P1*

Programmers, who are mainly quiet and passive people often lack the confidence to participate in the discussion on Stack Overflow. This hesitation can stem from a fear of making mistakes or being judged by other users. Additionally, the high standards and detailed knowledge expected in responses can be intimidating, further discouraging active participation.

"... maybe this is more personal since I happen to be a passive person." - *P3*

"... like answering on Stack Overflow or something like that, I'm not too sure yet, I'm not very confident yet." - *P4*

Programmers, especially those working in high-pressure environments, often lack the time to actively participate in threads on Stack Overflow. The demanding nature of their jobs leaves them with little opportunity to engage in online discussions, even when they recognize the potential benefits of knowledge sharing. The constant pressure to meet deadlines and the need to focus on immediate tasks take priority over contributing to forums. As a result, their participation in such communities is limited, which can impact the overall exchange of valuable information and support among programmers.

"Maybe I'm confident that if we want to share, it could help even more people. However, it might just be that I don't have the time for it yet." - *P3*

Passive in Stack Overflow but Active in Other Forums

While many programmers are not active on Stack Overflow, they are often more active on other forums. One of the interviewees, P1, stated that they use Telegram more because it is more flexible and does not require a complicated login process. Active engagement in other forums could be due to the convenience and ease of access offered by these platforms compared to Stack Overflow.

"... I am usually active on Telegram because it is more flexible, only need to chat, no need to log in..." – P1

Confidentiality Concern

Concern about the confidentiality of information is also a reason why some programmers are reluctant to share on Stack Overflow. P7 mentioned that sharing information regarding internal organizational issues on public platforms is not allowed due to the confidential nature of the information. This shows that the confidentiality factor can be a major barrier to knowledge sharing on public platforms.

> *"For sharing, if you go anywhere, to the website, no, because it's a matter of internal affairs, within the state, so you can't." – P7*

Always check from Google first

Before looking for answers on Stack Overflow, many programmers first look for solutions through Google. This habit is due to the speed and efficiency offered by the search engine. Google often directs users to Stack Overflow or other relevant sources, making it a quick first step in solving programming problems.

> *"The first time I do it, I usually search for the error on Google, because it's the fastest." – P4*

> *"Usually if it's like that, at first I will just search from Google first, then from Google it will also be directed to Stack Overflow." – P6*

Theme 2 - Importance of Stack Overflow as a Knowledge-Sharing Platform

Stack Overflow is The Swiss Army Knife of Programming Knowledge

Programmers now consider Stack Overflow to be a priceless resource due to its extensive collection of tools and solutions. It aids on a wide array of topics, from specific code-related issues to broader operating system problems. Because of the platform's vast knowledge base, developers may easily locate solutions to their queries, making it a valuable resource for both seasoned and inexperienced programmers. In the programming community, Stack Overflow promotes effective problem-solving and ongoing learning by making such a plethora of information accessible.

> *"I can find the solution to almost every problem I face on Stack Overflow. It's very helpful in my daily work." - P1*

> *"Stack Overflow is very, very useful because it has everything." - P2*

Stack Overflow is The First Gateway to Problem-Solving

Stack Overflow, as a knowledge-sharing medium, has become the go-to resource for programmers to solve any problems they encounter during the coding process. Its extensive database of questions and answers covers a vast array of topics, making it an indispensable tool for developers seeking solutions. This platform's role in fostering a collaborative and supportive community has solidified its place as a top resource in the minds of programmers worldwide, significantly enhancing productivity and efficiency. As mentioned by some participants:

> *"... before there was ChatGPT, Stack Overflow is the first gateway to finding solutions." - P4*

> *"Very important, because now Stack Overflow has become quite vital in terms of solving problems, becoming guidelines or the main reference place for getting solutions." - P6*

Theme 3 - Learning and Problem-Solving Processes

Self-exploration is The Key to Learning New Technologies

Programmers are often inclined to independently explore new technologies at first. This initial phase of solo experimentation allows them to develop a personal understanding and hands-on experience with the latest tools, frameworks, or programming languages. Once they have gained sufficient insight and confidence, they are more likely to share their discoveries and insights with their peers. This sharing can take various forms, such as informal conversations, detailed blog posts, or participation in online forums. When programmers join platforms like Stack Overflow to start discussions, it catalyzes a broader process of knowledge sharing. These interactions lead to a collaborative environment where ideas are exchanged, problems are solved collectively, and the overall knowledge base of the programming community is enriched. This cycle of exploration, sharing, and discussion not only helps individual programmers but also drives the continuous evolution and improvement of technological practices within the community.

> *"For new technology, I usually first explore it myself because I was a beginner fresh graduate you could say. So first I explore myself after that if I have stuck or the knowledge I have learned or the technology I have learned is by my limits, then I will discuss with my office mates about the new technology." - P1*

> *"Usually, if I have something new, I try to study it myself first, then if I get stuck, I ask my seniors or co-workers." - P2*

Reliance on Online Forums to Solve Problems

When facing issues, such as coding-related problems, programmers tend to use online forums like Stack Overflow, often through Google, to find solutions. However, when very specific problems occur or when there is a need to maintain secrecy around certain code or algorithms, programmers prefer to discuss these problems internally with their peers rather than post them on online forums. This approach ensures confidentiality while still leveraging collective expertise.

> *"For coding problems, I usually look for myself on Google or Stack Overflow, but if the problem is a bit heavy, I usually discuss the logic with the team or seniors first." - P5*

Theme 4 - Best Practices in Knowledge Sharing on Stack Overflow

Utilize as Many Online Forums as Possible

Some programmers may prefer to search multiple forums to find the best solution to a specific problem. This best practice method allows them to acquire as much knowledge as possible. By exploring a variety of sources, they can compare different approaches and select the most effective one. This thorough research process not only helps in solving the immediate issue but also broadens their understanding and skill set, making them more adept at tackling future challenges.

> *"For Java itself, I usually use Stack Overflow, then in telegram there are also many forums, then in hack rank, there are also forums ... it is quite helpful for new features in Java or SQL or whatever" - P1*

The Key is in The Details

When asking in Stack Overflow, there is a need to give a detailed context of the question. Also, make a clear end goal of the code provided. With this, respondents will fully understand the issue and the context of the problems so they can be more active in the forums.

"We must specify what the problem is. We also give what the evidence is like. So, it must be clear in advance what the problem being asked is. So that the party answering will understand the details of the problem." - P5

"The explanation of the problem must be as detailed as possible. Then for those related to hardware, the specifications of the hardware or software are also explained. So that those who answer can know the context of the system error as a whole." - P6

Be More Active

Participation of programmers is essential to ensure the quality of knowledge shared on Stack Overflow. By being active in the forums, they contribute their expertise, validate solutions, and provide valuable feedback. This active engagement helps maintain the accuracy and relevance of the information available, fostering a reliable resource for the entire programming community. Moreover, their involvement encourages a culture of collaboration and continuous learning, benefiting both novice and experienced developers.

"It's best to create a thread if the issue doesn't exist yet. We fill in the description available to create a thread and create a new post. We also adjust the tags. But if it's an old issue, then it's best if we can give an opinion or solution, by replying to other people's posts. If for example in the post there is already a solution and the solution can be used by us, then we give an upvote to the answer, the value is getting bigger, also giving a reward to the answer giver." - P4

Table 3 below summarizes the main themes that emerged during the FGDs. Each theme is associated with a respondent who mentioned the theme during the discussion. For example, the theme 'Passive Usage Patterns' was identified by four respondents who acknowledged that they often search for information on Stack Overflow without actively contributing.

Table 3. Summary of Key Themes and Respondents in FGDs

No.	Main Theme	Theme Description	Respondents who Mentioned Themes
1	Passive Usage Patterns in Stack Overflow	Users often search for information already available on Stack Overflow without actively participating, such as asking questions or answering questions.	P1, P3, P6
2	Concerns about Confidentiality	Concerns over the confidentiality of information prevent some users from sharing knowledge on open platforms such as Stack Overflow	P2, P7
3	Use of Other Forums (Telegram, etc.)	Some users are more active on other platforms such as Telegram due to ease of access and flexibility	P1
4	Learning Process and Problem Solving	Users tend to do independent exploration in learning new technologies before sharing their findings	P1, P2, P5
5	Best Practices in Knowledge Sharing on Stack Overflow	Ensure there is clear detail in the question and use various forums to find the best solution.	P4, P5, P6

The results of this study were obtained through several analytical steps. First, data was collected through Focus Group Discussions (FGDs) with seven respondents who have experience using Stack Overflow. Second, the data obtained from the FGDs were transcribed and analyzed using the Thematic Analysis method, where key themes were identified and grouped. Each emerging theme was identified based on

its frequency of occurrence in the discussion, as well as its relevance to the research questions. Third, these themes were then presented and further analyzed to understand the patterns of knowledge sharing in Stack Overflow. In the process of analysis, preliminary findings showed that most respondents engaged in passive usage patterns, which were then further analyzed to identify factors influencing such behavior. Factors such as concerns about confidentiality and lack of motivation to actively participate emerged as key themes that helped the researcher understand the challenges faced by Stack Overflow users. Ultimately, these findings provide the basis for recommendations on how the platform can increase active participation. By presenting a table of themes and respondents supporting each theme, as well as explaining the steps taken during the analysis process, the results of this research become more structured and easier to understand. It also provides a more complete picture of how the final insights were derived from the data collected.

Discussion and Implications

This research reveals two main aspects of knowledge sharing patterns in Stack Overflow, namely the pattern of users in sharing knowledge and the best practices that can be done to share knowledge effectively. Only two aspects of knowledge sharing were covered in the discussion as these themes directly address the research questions. Theme 1 reflects users' patterns of knowledge sharing, while theme 4 focuses on best practices, which are particularly relevant for answering the second question. Thus, the discussion centered on these two themes to keep the focus on the main objective of the research. Theme 1, which focuses on passive usage patterns, answers the first research question of what are the user patterns in knowledge sharing. This pattern emerged as dominant in the data and reflects passive engagement on Stack Overflow. Meanwhile, theme 4 on self-learning processes and knowledge sharing best practices on Stack Overflow answered the second research question.

User Patterns in Knowledge Sharing on Stack Overflow

Meanwhile, all FGD participants agree that Stack Overflow is their main source of problem-solving solutions to all their code-specific problems as stated by the second theme. However, all participants still lack the motivation to be active in knowledge sharing especially in Stack Overflow. These usage patterns can be caused by many factors like the nature of stack overflow itself, the quiet and introverted nature of programmers, and time constraints.

Based on the interview results and thematic analysis, the main pattern identified is the passive use of the Stack Overflow site. Most respondents use the site to find solutions to programming problems they face but rarely actively participate by posting questions or answers. For example, some respondents stated that they often rely on Stack Overflow to find solutions but do not actively contribute by providing answers or asking questions. One of the main reasons for this passive usage is that programmers believe many of their problems have already been asked and solved in the forums, so they don't feel the need to ask the same questions. These findings are similar to the study conducted by Nguyen (2021), which indicates that people tend to be 'lurkers' because they think just reading and browsing is enough. This suggests that many lurkers can get their needs met through observation rather than public participation.

The nature of programmers themselves is another factor contributing to the passive usage of Stack Overflow. Since programmers are frequently introverted, quiet, and passive people, they are more prone to absorb information than actively contribute to knowledge sharing. This introverted tendency means they prefer to observe and learn from existing discussions rather than engage in them. They might find it more comfortable to absorb knowledge in private than to participate in public forums. They might stay in the background and learn silently out of fear of receiving unfavorable comments or condemnation from more seasoned peers. These findings have similar results to the research conducted by Lv et al (2022), who conducted similar research in the healthcare context. Their research found that introverted users are more likely to engage in knowledge-sharing forums passively rather than actively contributing. The same result was also highlighted by Jami Pour and Taheri (Jami Pour & Taheri, 2019), who found that a lack of trust in introverted individuals affects their willingness to share knowledge. This tendency to observe rather than participate actively highlights a common behavior pattern across

different fields, where introverted individuals prefer to absorb information quietly instead of publicly sharing their insights and experiences.

Passive usage can also be caused by time constraints. Programmers, who frequently work in high-pressure environments with limited time, often find it challenging to share their knowledge. The demanding nature of their jobs leaves them with little energy or opportunity to engage in online discussions or contribute to forums like Stack Overflow. Consequently, while they may benefit greatly from the resources available on such platforms, their contributions remain minimal due to these constraints. These findings can also be found in the research conducted by Li et al (2023), who found that time pressure negatively impacts knowledge-sharing intention because it increases emotional exhaustion. Costin et al (2023), also found time constraint is a significant barrier that affects physicians' intention to share knowledge.

In addition, some programmers were more active in other forums for reasons of convenience and ease of access. For example, P1 stated that they use Telegram more often because it is more flexible and does not require a complicated login process. This active engagement in other forums could be due to the convenience and ease of access offered by these platforms compared to Stack Overflow. This suggests that programmers are looking for platforms that are more user-friendly and efficient in sharing knowledge.

Concerns about the confidentiality of information are also a reason why some programmers are reluctant to share on Stack Overflow. P7 mentioned that sharing information related to internal organizational issues on public platforms is not allowed due to the confidential nature of the information. This suggests that the confidentiality factor could be a major barrier to knowledge sharing on public platforms. Therefore, it is important for platforms like Stack Overflow to consider features that can keep user information confidential.

The habit of searching for answers through Google before searching on Stack Overflow reflects the efficient use of online resources by programmers. This habit is due to the speed and efficiency offered by search engines. Google often directs users to Stack Overflow or other relevant resources, making it a quick first step in solving programming problems. This suggests that better integration between search engines and Stack Overflow could improve information accessibility.

Best Practices in Knowledge Sharing on Stack Overflow

Meanwhile, all participants agree that Stack Overflow is an invaluable asset to programmers as a problem-solving tool. There is also some emphasis on self-exploration of new technology, this exploration aims to increase self-expertise, which in turn can improve the quality of knowledge shared on Stack Overflow. This has been explained by Al Mamun & Lawrie (2023), who stated that people who engage in deep self-exploration of new knowledge tend to have better learning outcomes and are more likely to share their knowledge effectively.

After self-exploration, the next step is to share the knowledge. All participants have developed their way of sharing knowledge effectively in online forums. Their 'best practices' have their benefits and step back. But every 'best practice' can lead to a better knowledge-sharing experience and a better quality of the knowledge shared.

The best practices identified in this study include several strategies that can improve the effectiveness of knowledge sharing on Stack Overflow. The first best practice proposed will be using multiple forums/websites instead of only using Stack Overflow. Integrating Stack Overflow with any outside resources like another forum, tutorials on YouTube, or any other sites, and official documentation of the programming language will enrich the knowledge acquired by the programmer. This can lead to a better solution to a code and will improve decision-making. A similar finding can also be found in the research conducted by Samuelsen et al (2019), who found using multiple learning sources improves the knowledge-sharing experience by providing richer insights. Kirk et al (2022), also found that using multiple knowledge sources will improve learning efficiency.

Another best practice identified is that the more active you are in the forums, the better your knowledge-sharing experience becomes, which in turn improves the quality of the shared knowledge. Active

participation allows individuals to engage in discussions, ask questions, and provide answers, fostering a collaborative environment. This continuous interaction not only enhances personal expertise but also contributes to the overall richness and accuracy of the information available on the platform. By regularly participating, users can stay updated with the latest developments, refine their understanding, and help create a more comprehensive and reliable knowledge base for the entire community. The same results were also found in the research conducted by Marco-Fondevila et al (2022), who found that the students who have more active interaction in a forum will have improved knowledge, which improves academic performance and motivation to share their knowledge. Similar results were also found by Khan et al (2021), who found that being more active in forums and social media platforms enhances the knowledge-sharing experience by improving communication, increasing engagement, enhancing learning performance, and boosting motivation and enjoyment.

The final best practice identified from the FGDs is that when asking a question in a forum, it needs to be detailed, clear, and provided with context. Doing so improves the quality of the question, making it easier for respondents to understand. This clarity helps ensure that the answers provided are more accurate and helpful, ultimately enhancing the overall effectiveness of the knowledge-sharing process. The same results are also being discussed by de Lima et al (2019), who found that detailed questions in online forums enhance the knowledge-sharing experience by providing clarity, encouraging in-depth discussions, improving engagement, and facilitating better learning. These factors collectively contribute to a richer, more effective knowledge-sharing environment. This was also proved by Zou et al (2023), who showed that detailed questions can improve the knowledge-sharing experience by encouraging in-depth discussion. Which in turn, can improve the knowledge acquired.

While none of the seven programmers explicitly mentioned using AI such as ChatGPT as a replacement for Stack Overflow, global trends show an increase in the use of AI tools. According to a report by Stack Overflow (2023), 70% of developers already use or plan to use AI tools in their workflows, suggesting that AI is growing in popularity as an alternative to getting quick answers. AIs like ChatGPT allow programmers to get instant answers without the need to wait for a response from the community, which can reduce active interaction on platforms like Stack Overflow. However, research by Kabir et al (2024) found that 52% of answers generated by ChatGPT contained errors, even though users appreciated the readability and clarity of the answers. This suggests that while AI provides quick solutions, the quality of answers from the community on Stack Overflow still provides value.

This research reveals five key aspects or implications of knowledge sharing patterns on Stack Overflow. These aspects include various factors that influence user engagement, both in active and passive contributions on the platform. Each of these aspects plays an important role in understanding the dynamics of information sharing among users, as well as the factors that can enhance or hinder their participation.

Increasing Active Participation

The findings from this study reveal a significant gap between passive and active participation on Stack Overflow. Although the platform is widely used to search for solutions, the low level of active contributions hinders the potential for richer knowledge exchange (Mahbub et al., 2021). To increase active participation, Stack Overflow could consider strategies such as gamification and recognition systems to motivate users. Awards for valuable contributions and public recognition of participation can encourage more users to actively participate. Additionally, creating a more supportive environment for beginners with helpful guides and tutorials could increase new user engagement.

Overcoming Psychological Barriers

The introverted nature of many programmers combined with the fear of negative feedback greatly affects their desire to engage in active discussions. Overcoming these psychological barriers is important for building more inclusive and collaborative online communities. Platforms like Stack Overflow can implement an anonymous posting option to alleviate users' concerns about public criticism. While anonymity can encourage more users to share their knowledge, it can also lead to irresponsible behavior and disruptions, such as cyberbullying (Lee et al., 2020). In addition, providing

mentoring programs where more experienced users can help and guide beginners can encourage more active participation. Encouraging a culture of positive and constructive feedback can also reduce the fear of negative feedback and increase users' confidence to share knowledge.

Time Management and Knowledge Sharing

Time constraints are a significant barrier to active participation. Programmers often struggle to balance demanding work schedules with the time required to make meaningful contributions on the forum. Organizations and platform administrators can play a role in addressing this issue by integrating knowledge sharing activities into routine work processes (Shi et al., 2020). For example, encouraging employees to allocate dedicated time to contribute on forums such as Stack Overflow can improve both individual and organizational knowledge bases. Providing tools and resources that make it easy to share knowledge efficiently can also help overcome time constraints.

Improving Question Quality

This research emphasizes the importance of formulating detailed and contextualized questions to improve the quality of answers on Stack Overflow (Galappaththi et al., 2022). Educating users on best practices in asking questions, such as providing clear context, being specific about the problem, and outlining solutions that have been tried can improve the overall effectiveness of the knowledge sharing process. Stack Overflow can provide guidance and examples of good questions to help users understand how to ask more effective questions. By improving the quality of questions, the community can provide more accurate and useful answers, thus improving the overall knowledge sharing experience.

Implications for Platform Design

The findings of this study also have implications for the design of the Stack Overflow platform and similar forums. Features such as better integration with search engines (Chen et al., 2019), anonymization options, and tools to make knowledge sharing easier could increase user engagement. In addition, platforms may consider developing features that allow users to share knowledge more efficiently, such as automated tools to identify similar questions or personalized recommendation features. By continuing to innovate and customize platform features based on user feedback and research findings, Stack Overflow can improve the effectiveness and efficiency of knowledge sharing in the community of programmers.

In terms of theoretical implications, this study found that privacy concerns and passive usage patterns play an important role in inhibiting active participation in Stack Overflow, something that has not been widely discussed in previous research. Studies such as Zamiri & Esmaeili (2024) focused more on the technology use and social aspects of knowledge sharing, but did not touch on the psychological aspects related to privacy. As such, this study offers a novel contribution to the literature, by highlighting how privacy concerns can affect user engagement on knowledge sharing platforms. These psychological factors expand the understanding of the barriers faced in online communities, which have previously focused more on social and technical motivations.

Conclusion

This research reveals two main aspects of knowledge sharing patterns on Stack Overflow, namely user patterns in knowledge sharing and best practices that can be done to share knowledge effectively. The main usage pattern identified was passive use of the Stack Overflow site. Most respondents use the site to find solutions to programming problems they face but rarely actively participate by posting questions or answers. Factors such as programmers' introverted nature, time constraints, and the belief that their problems have been addressed before contribute to this passive use. In addition, concerns about the confidentiality of information and a preference to search for solutions through Google before Stack Overflow also influenced this usage pattern.

On the other hand, all participants agreed that Stack Overflow is a very valuable asset for programmers as a troubleshooting tool. Best practices identified to improve the effectiveness of knowledge sharing

include using forums or websites other than Stack Overflow, active participation in forums, and asking detailed and clear questions. These practices can improve the quality of knowledge shared and help create a more comprehensive and reliable knowledge base for the entire community of programmers.

This research also highlights the importance of addressing the psychological barriers and time constraints that programmers face to increase their active participation on Stack Overflow. Strategies such as gamification, recognition systems, and creating a more supportive environment for beginners can motivate users to participate more actively. Additionally, the implementation of anonymous posting options and mentoring programs can alleviate concerns about negative feedback and confidentiality of information.

Overall, this study provides deep insights into Stack Overflow usage patterns and best practices in knowledge sharing. The findings can be used to improve user engagement and the quality of knowledge shared on this platform, and encourage further research into the psychological and social factors that influence active participation in online forums such as Stack Overflow.

Limitation and Future Work

This study has several limitations. Firstly, the relatively small number of respondents may limit the generalizability of the findings. Secondly, this study only involved respondents who already had experience using Stack Overflow, so it may not represent the perspective of programmers who have never used this platform. Thirdly, this study uses a qualitative approach that relies on the researcher's interpretation, so there may be subjectivity bias in the data analysis. Lastly, this study did not explore in-depth external factors such as company policies or organizational culture that might influence knowledge-sharing behavior.

Future research can expand the scope by involving more respondents from various industry backgrounds and different experience levels to get a more comprehensive picture of knowledge-sharing patterns. In addition, research can be conducted to explore the psychological and social factors that influence active participation in online forums such as Stack Overflow. Further studies could also develop interventions or tools designed to encourage active participation and improve the quality of knowledge shared on these platforms.

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How to cite:

Wirabuana, C., Ridho, M. M., Sensuse, D. I., Eitiveni, I., Hidayat, D. S., Sofiyanti, I. (2025). Patterns and Best Practices of Knowledge Sharing among Programmers on Stack Overflow: A Qualitative Study. *Jurnal Sistem Informasi (Journal of Information System)*, 21(1), 59–81.