

Master Thesis on the subject of

Use and Impact of Forums and AI-based Support on Students' Programming Practices

Degree course:	MSc. Computer Science
Handed in by:	Muhammad Shoaib Hussain
Enrolment number:	219100223
Work period:	01. Nov 2024 – 21. March 2025
Supervisor:	Prof. Dr. rer. nat. Regina Hebig
Primary Reviewer:	Dr.-Ing. Helge Parzyjgla



This work is licensed under a Creative Commons Attribution 4.0 International License.

Contents

1	Introduction	1
1.1	Research Questions	2
2	Background	3
2.1	LLMs for Software Engineering	3
2.2	StackOverflow	4
2.3	ChatGPT	4
3	Related Work	5
3.1	Exploring students' preferences between AI-powered ChatGPT, and human-curated Stack Overflow in resolving programming problems and queries. . .	5
3.2	Which is a better programming assistant? A comparative study between ChatGPT and stack overflow.	6
3.3	ChatGPT Is Here to Help, Not to Replace Anybody - An Evaluation of Students' Opinions on Integrating ChatGPT in CS Courses.	7
3.4	Is Stack Overflow Obsolete? An Empirical Study of the Characteristics of ChatGPT Answers to Stack Overflow Questions.	7
3.5	Student Experiences with GitHub and Stack Overflow: An Exploratory Study.	8
3.6	Exploring GitHub Copilot assistance for working with classes in a programming course.	9
3.7	AI for coders: An analysis of the usage of ChatGPT and GitHub CoPilot. . . .	10
4	Method	13
4.1	Interview design and data collection	13
4.2	Interviewees	16
4.3	Data Analysis of Interviews	17
4.4	Demographics	19
5	Results	21
5.1	Forums / Stack Overflow Effects on Learning	21
5.1.1	General answers force training of problem-solving skills:	21
5.1.2	Exposure to other peoples' minds:	22
5.1.3	Learning goals that were successfully supported by forums	22
5.1.4	Preference for Generative AI, due to time saved.	24
5.2	Reliability & Quality of Generative-AI / ChatGPT Solutions	25

CONTENTS

5.2.1	Switching between ChatGPT and Forums	26
5.2.2	Project security in Generative AIs/ChatGPT	27
5.2.3	ChatGPT answers are reliable:	27
5.3	Reliability & Quality of Forums/ Stack Overflow Solutions	28
5.3.1	Solutions on forums are not reliable:	31
5.4	Effects of Generative AI & Forums on learning	31
5.5	Effects of Generative AI /ChatGPT on Learning	33
5.5.1	Generative AI / ChatGPT is effective for learning	34
5.6	Efforts to get solutions/ answers in Forums/ Stack Overflow	35
5.7	Time to get solutions/ answers in Forums	37
5.8	Efforts to get solutions/ answers in Generative AI/ChatGPT	39
5.9	Time to get solutions/ answers from Generative AI/ ChatGPT	41
5.10	Purpose of using Forums/Q&A Platforms	43
5.11	Purpose of using Generative AI / LLMs	45
5.12	Preference/Order of using forums & generative AI support	46
5.13	Will ChatGPT substitute Stack Overflow?	47
5.13.1	ChatGPT & Co. will not substitute Stack Overflow & others:	48
5.13.2	ChatGPT & Co. will substitute Stack Overflow & others:	48
5.14	Lacking features in ChatGPT and/or Stack Overflow	49
5.14.1	Features lacking in ChatGPT:	49
5.14.2	Features lacking in Stack Overflow:	51
5.15	Usefulness of ChatGPT & Stack Overflow	52
5.15.1	Usefulness of ChatGPT:	52
5.15.2	Usefulness of Stack Overflow:	53
5.16	ChatGPT is the Preference	53
5.17	Preference is Stack Overflow	55
5.18	Usefulness of ChatGPT	56
5.19	Usefulness of Stack Overflow	57
6	Discussion	59
6.1	RQ1: When do students use forums like Stack Overflow, during programming tasks?	59
6.2	RQ2: When do students use AI assistance like ChatGPT, during programming tasks?	60
6.3	RQ3: How do they perceive both technologies in comparison?	60
6.4	Comparison of Results to Related Work	62
7	Conclusion and Future Work	65
7.1	Conclusion	65
7.2	Future Work	66

Abstract

In this thesis, we aim to investigate the research questions related to forums, such as Stack Overflow, and Generative AI, like ChatGPT. We also investigate how students perceive both platforms and AI-based support in comparison. We conducted a qualitative interview study with 19 students and used card-sorting techniques to identify themes and patterns in their responses. We found out students used forums and AI-based support mainly for learning and understanding different programming languages, problem-solving, cross-verifying solutions, getting quick responses, and saving time, among other things. Our study demonstrated that students perceive forums as more reliable platforms but perceive generative AI/LLMs as time-efficient and effortless.

Acknowledgement

I received great encouragement and support while writing this thesis.

I would like to thank Prof. Dr. rer. nat. Regina Hebig and Dr.-Ing. Helge Parzyjega for trusting me and giving me this opportunity. Your feedback was very helpful in rectifying my mistakes when I felt lost and helping me to increase the quality of my work.

I would also like to thank all the students who participated in this study, who spared their precious time and invaluable insights for the interviews, and last but not least, my family, who was emotionally supportive throughout my journey.

Introduction

In this chapter

1.1	Research Questions	2
-----	------------------------------	---

Artificial Intelligence nowadays has become one of the most advanced and powerful fields of Computer Science, which not only plays a vital role in our daily lives but also provides us with day-by-day improvements to our way of living. The technology that allows computer machines and other devices to mimic human learning, comprehension, problem-solving, decision-making, creativity, and autonomy is known as artificial intelligence (AI) [ibma]. It also includes understanding natural language and recognizing patterns. From the fields of healthcare, finance, and transportation to the world of entertainment, it helps to reduce human effort from our daily routine by performing required tasks. Artificial Intelligence has become a broader field of computer science, consisting of several key components, including machine learning, robotics, computer vision, and others.

One of the major branches of artificial intelligence (AI) is natural language processing (NLP), which employs machine learning to make it possible for computers to comprehend and interact with human language [ibmb]. NLP helps machines understand human language by applying techniques like text summarization, sentiment analysis, and information retrieval [Gee]. Virtual help and chatbots, where programs like Siri, Alexa, and ChatGPT can understand and reply to user inquiries in natural language, are among its important uses.

NLP, the branch of AI that deals with the interaction between computers and human language, also includes advanced NLP models trained on vast amounts of text data to understand and generate human-like language known as Large Language Models (LLMs). LLMs can produce helpful language output generally built on deep learning techniques like transformers.

They can thus be proficient in various language-related activities, such as sentiment analysis, translation, answering queries, and text production. There are several popular examples of LLMs that are being commonly used, such as the GPT series developed by OpenAI, Claude designed by Anthropic, Bard created by Google, LLaMA (Large Language Model Meta AI) from Meta, and others [Fan+23]. These models vary in their architectures, training methods, and intended use cases, but they all aim to advance natural language understanding and generation.

1.1 Research Questions

The following research questions is what we hope to address in this thesis:

RQ.1: When do students use forums like Stack Overflow, during programming tasks?

RQ.2: When do students use AI Assistance like ChatGPT, during programming tasks?

RQ.3 How do they perceive both technologies in comparison?

Background

In this chapter

2.1	LLMs for Software Engineering	3
2.2	StackOverflow	4
2.3	ChatGPT	4

2.1 LLMs for Software Engineering

Although LLMs have been extensively utilized for work involving natural languages, they have also received a lot of interest lately for their applicability to software development tasks involving programming languages.

A refined GPT-3 descendent called CodeX was unveiled by OpenAI in 2021. GitHub's Copilot leverages CodeX to offer code completion to Visual Studio Code, Visual Studio, Neovim, and JetBrains users. GitHub Copilot X, the latest iteration of Copilot, is built on top of GPT-4 [Fan+23]. Also, DeepMind unveiled AlphaCode in 2022; it was trained using 40 billion parameters on a subset of public GitHub repositories. In competitions with over 5,000 participants, it averaged a position in the top 54% of simulated evaluations [Li+22].

Similar to human coders, GPT-4 performs comparably on a benchmark of 100 LeetCode tasks [Bub+23]. On the 24th of August 2023, Meta released open-sourced Code Llama, a state-of-the-art for publicly available LLMs on coding tasks [Roz+23].

The above-said LLMs have been introduced to make the coding task related to software engineering more seamless and enable developers to efficiently improve coding workflow. By providing intelligent code recommendations and in-the-moment support, these tools promise to increase developers' productivity by streamlining their workflow.

2.2 StackOverflow

Programmers frequently use online resources for various programming tasks, such as understanding APIs, resolving bugs, analyzing code or concepts, etc. Most help-seeking actions involve regularly using community Q&A sites like StackOverflow [Kab+24]. In the world of software development and computer programming, Stack Overflow is a crucial resource [CKP20]. Since its founding in 2008, Stack Overflow has become a well-known resource for programmers of all experience levels looking for answers, knowledge, and interaction with like-minded individuals. This platform's user-generated content is its main advantage [TIH20]. Users often ask questions about coding difficulties, and they get answers that address these difficulties and promote a cooperative knowledge-sharing atmosphere [Gar+23]. This collaborative ecosystem produces a collection of best practices, insightful analysis, and inventive solutions that accommodate a variety of programming languages, frameworks, and domains.

2.3 ChatGPT

Since its launch in November 2022, ChatGPT has grown in popularity among programmers of all skill levels. ChatGPT functions as a conversational chatbot that enables users to ask questions and provide assistance for code completion, which is one of its primary advantages over StackOverflow. Programmers, for example, can ask for an explanation of a code, ask how to fix an error message, or ask a conceptual question about a data type utilized in a program [Kab+24]. The possibility of a response delay is one of the frequent obstacles to using Stack Overflow [BMS21]. This barrier prevents users from getting the quick help they need to solve programming issues. On the other hand, students indicated that the capacity of ChatGPT to provide prompt, mostly accurate answers to their questions is a major benefit of integrating it into their programming education [YY23]. Creating instances of code snippets, spotting defects in provided code, recommending improvements for existing code structures, and even automatically fixing logical and syntax mistakes are some of its most important applications. As such, it has the potential to be a very useful auxiliary tool for coding.

The emergence of Large Language Models (LLMs) has shown promise in changing programmers' online help-seeking behavior. ChatGPT became very well-known and popular among programmers. Researchers and business professionals have been debating whether and when ChatGPT will replace the role of well-known search engines and Q&A forums like StackOverflow [x][Quo].

Related Work

In this section we discuss related work on topics concerning forums such as Stack Overflow, GitHub, etc., as well as AI-based support like ChatGPT, CoPilot, and others.

3.1 Exploring students' preferences between AI-powered ChatGPT, and human-curated Stack Overflow in resolving programming problems and queries.

One of the recent papers was published last year by researchers exploring students' preferences between AI-powered ChatGPT and human-curated Stack Overflow in resolving programming problems and queries [Gar+23]. This study sought to determine which of these sites were preferred for answering their programming queries by student programmers. The study explores users' judgments of general preferences, cognitive effort, information scent, utility, and ease of use. The results indicate noticeable differences in preferences among the 120 students in the group (i.e., website, application, and game developers).

There are multiple results between different groups of students:

- a. Overall preferences- have seen huge differences between groups of students (i.e., website, application, and game developers) when it comes to choosing ChatGPT or Stack Overflow, which is not only influenced by their features and qualities but also by students' respective fields and backgrounds.
- b. Cognitive effort- showed a significant difference in using ChatGPT over Stack Overflow due to inconsistent responses to users' queries.

c. Information scent- identifies a notable difference between ChatGPT and Stack Overflow because of the benefit of assisting students in finding pertinent information.

The study also discussed within-group preferences and cognitive use of students, among others. However, it was restricted to a single platform and tool to analyze its use and impact among students. Furthermore, it focused on the quantitative approach to figure out preferences between these two online support (i.e., ChatGPT and Stack Overflow) in contrast to our research, which mainly focuses on a qualitative approach and not only helps to gather the relevant data/information but also to achieve meaningful insights from target audience necessary to reach the outcomes from it.

3.2 Which is a better programming assistant? A comparative study between ChatGPT and stack overflow.

Another comparative research study between ChatGPT and Stack Overflow addresses the question of which is better for programming assistants [Liu+23]. Although programmers can benefit significantly from both systems, finding which one will increase their productivity is vital. The authors conducted a user study to compare both platforms regarding programmer productivity enhancement. Researchers experimented on two groups of students with the same skill sets and instructed them to use both platforms for their tasks: debugging, algorithmic challenges, and usage of programming libraries. Researchers recorded and contrasted the two groups' time spent on tasks and the quality of code they generated throughout the trials.

In the algorithmic challenge, the ChatGPT group outperforms the Stack Overflow group regarding task completion speed, while the two groups perform similarly in the other two challenges. The findings also demonstrate that ChatGPT performs noticeably better than Stack Overflow regarding code quality when assisting with algorithmic and library-related activities, while Stack Overflow is superior for debugging tasks. Furthermore, to learn more about how the platforms assisted the participants in completing the programming tasks, researchers also administered a post-experiment survey involving 44 participants in questionnaires to compile the strengths and weaknesses of ChatGPT and Stack Overflow as reported by the respondents.

Regarding their strengths and weaknesses, ChatGPT performs well in library and algorithmic tasks due to its fast code generation compared to Stack Overflow. On the other hand, as the authors reported, Stack Overflow is proficient in resolving explicit exceptions and offering beneficial links, so it has an edge in debugging jobs.

The research is divided into two parts to determine which platform is better for programming assistance (e.g., ChatGPT and Stack Overflow). The latter part emphasizes only the platforms'

strengths and weaknesses. However, we will use qualitative interviews to discover what situations/scenarios and by which preferences students use such platforms to gain a more profound understanding.

3.3 ChatGPT Is Here to Help, Not to Replace Anybody - An Evaluation of Students' Opinions on Integrating ChatGPT in CS Courses.

This research paper evaluates students' opinions regarding the adaption/integration of Computer Science courses with OpenAI's ChatGPT [CA24]. The authors of this research conducted surveys in the form of questionnaires answered by (52) Computer Science students in the first year of their degree program to gauge their opinions on code-generation technologies from both an academic and professional standpoint.

The study discovered that 1) A large proportion of students (84.6%) will use GPT in an assignment if instructed to do so, and most students will use it even if it is not required of them, despite the percentage being small (69.2%). Students generally have favorable judgments about these resources and how they are used in the classroom. 2) ChatGPT usage between students without formal training suggests that they can use it well. However, some students cannot get optimal results due to their lack of 'prompting skills.' 3) Although most students found their use of ChatGPT in terms of learning helpful, some percentages of students (27%) found it less helpful for their respective tasks. 4) Although students are unsure that such technologies will lessen the demand for programmers, they tend to believe that integrating ChatGPT exercises in computer science courses will benefit their professional careers.

However, the paper has discussed a couple of research questions, but as far as the methodology is concerned, the authors have implemented a quantitative approach based on questionnaires of several types of questions (e.g., Yes/No, 1-5, percentages, and others), as opposed to our study, which primarily employs a qualitative approach with the help of interviews. Also, the students mentioned in this research are in the initial stage of their respective degrees and might have less experience in programming skills and knowledge sets.

3.4 Is Stack Overflow Obsolete? An Empirical Study of the Characteristics of ChatGPT Answers to Stack Overflow Questions.

The authors of this paper [Kab+24] claim the first thorough analysis of the features of ChatGPT's responses to programming queries. They analyzed 517 StackOverflow programming queries answered by ChatGPT to examine their correctness and consistency, among other

factors. The researchers conducted different methodologies for their research questions, including semi-structured interviews with 12 participants, linguistic and sentiment analysis, and in-depth manual analysis.

The most relevant findings of the paper, amongst others, reported 1) that 78% of ChatGPT responses are inconsistent with human responses, 77% of ChatGPT responses are prolonged, and more than half of ChatGPT responses contain inaccurate information. On the other hand, ChatGPT responses are detailed and address various topics related to the questions and responses. 2) For code answers, ChatGPT rarely makes syntax errors. Employing incorrect reasoning or implementing nonexistent or inaccurate APIs, libraries, and functions accounts for most code errors. 3) ChatGPT responses exhibit more appealing sentiments than StackOverflows' human responses. 4) More than 80% of individuals can accurately distinguish ChatGPT responses from human responses. They consider formal language, structured writing, answer length, and odd errors to determine whether ChatGPT produced a response. 5) Because ChatGPT answers are thorough, clearly expressed, and lifelike, users miss identifying inaccurate knowledge 39.34% of the time. 6) 65.18% of the participants prefer Stack Overflow's human responses over ChatGPT. Respondents deemed human responses to be more accurate, straightforward, and helpful.

Although the study showed the percentages of responses from AI-based technologies such as ChatGPT, which is more attractive to participants, most of the research is bound to the misinformation and correctness of data along with the linguistic and sentiment analysis as well as manual analysis of ChatGPT responses, in contrast to our research also focuses on the factors such as usefulness, learning, reliability, preferences between such technologies.

3.5 Student Experiences with GitHub and Stack Overflow: An Exploratory Study.

In this research paper [BMS21], authors have pointed out the barriers and challenges of contributions in different social platforms, including StackOverflow and GitHub (an open-source platform) used by programmers for their respective codes and projects. Researchers opted for qualitative research analysis by conducting semi-structured interviews with 20 participants to learn more about the students' individual experiences, behaviors, opinions, and views towards these platforms.

In their initial findings, authors mentioned using these platforms for school or job-related projects. Most of the research participants have utilized Stack Overflow and GitHub at some point while pursuing their degrees. However, few of them have actively used both.

While mentioning the core finding of the study, researchers discussed some of the main barriers to participating in StackOverflow and GitHub platforms are 1) lacking self-confidence due

to insufficient or minimal coding skills, 2) prefer to stay in one's comfort zone because of their shy and introvert behaviors, and not felt more at ease interacting with members of their unfamiliar social networks, 3) barrier regarding time-limitations which addressed out the time-oriented issues in participants due to their school and job-related commitments bared them to contribute, 4) Stack Overflow is not the most apparent place to look for assistance claimed by some interviewees, because they did not usually seek help from StackOverflow; instead they prefer search engines and follow links for their answers.

5) Seeking a prompt response: Some participants said they never post anything on Stack Overflow because posting queries and waiting for answers from other community members takes too long. These individuals would instead read other sources and figure out the answer independently. 6) the Stack Overflow community sets low expectations, which is another obstacle raised by the researchers since some respondents believed that their problems were usually project-specific and that no one else would understand their inquiries if they were posted to Stack Overflow. At the same time, others thought that they preferred to search for their desired answer deeply since the community could find their inquiries strange. 7) reluctant to assist others is another significant barrier that describes the state of no will to give back to the community for some students, as it is sufficient to read and use the responses they search for.

The researchers cite multiple obstacles caused by different students' behaviors in this paper. However, the study strictly focused on the issues raised in social platforms like StackOverflow and GitHub, contrary to our research, which also aims to highlight the experiences and impact of AI-based support like ChatGPT on student programming practices.

3.6 Exploring GitHub Copilot assistance for working with classes in a programming course.

This paper [Men23] investigates how to incorporate the AI programming assistant GitHub Copilot into beginning object-oriented programming (OOP) classes. It draws attention to the potential difficulties that students may encounter when learning OOP principles because of their abstract nature and how Copilot might help by offering completion and code suggestions. The qualitative study assesses how students engage with Copilot in code-generation task situations and offers instructional modifications that teachers can use to integrate this AI tool into programming instruction successfully.

With an emphasis on object-oriented programming, the paper offers a descriptive case study that examines how GitHub Copilot is used to solve fundamental issues in an elementary programming course. It acknowledges selection bias in these choices and offers two different usage scenarios based on the researcher's experience as a course instructor. The study strongly

emphasizes thorough data collection and documentation, researcher bias avoidance, and validation using student questionnaires to improve dependability. The research focuses on two primary scenarios of programming problems that arise in the initial stages of an introductory OOP course; to produce code and recommendations for such scenarios, consider Copilot's responses to the study.

1. Use-task Scenario: Copilot generates code in response to textual prompts from the programmer in the Integrated Development Environment (IDE). This scenario relies on comprehending pre-written code statements and using class structure knowledge to construct the intended application.
2. Create-task Scenario: In this scenario, the programmer types code statements in the IDE and gets Copilot's recommendations on finishing or altering the code. This scenario aims to produce class code that satisfies particular application needs.

Six application scenarios for use-type and create-type activities were investigated in the study, where the accuracy of the code produced, as well as the frequency of rewritten prompts, were examined. The number of attempts to enhance solutions varied, even though the initial prompts were comparably complex across domains. Most prompts needed to be rewritten to be more precise by standardizing method names and employing instructions that resembled pseudo code. In order to achieve a final accuracy of 90%, applications also have to learn how to collect user input based on high-level criteria.

The research has proposed teaching a programming course using Generative AI. However, the research explores the situations and scenarios of using GitHub's CoPilot while learning. It describes the idea of teaching such technologies from the educator's perspective, in contrast to our research, which dominantly focused on students' points of view and opinions on the usage of Generative AI and different forums.

3.7 AI for coders: An analysis of the usage of ChatGPT and GitHub CoPilot.

The study [PK24] showcases the usage of GitHub's CoPilot and OpenAI's ChatGPT among IT programmers and non-professionals from different backgrounds. Researchers have used StackOverflow's annual developer survey as a database to investigate not just the popularity of such technologies but also try to explain whether and to what extent programmers have used them simultaneously.

The study used data from the May 2023 Stack Overflow Annual Developer Survey, which had over 90,000 responses. Because the responses were comprehensive and received the participants' permission to disclose their information, 89,184 of these responses were considered

"qualified" for the study. The data were analyzed using SPSS 29 software to implement a range of statistical measures. A literature review was also created using Chat GPT-4, which also helped with sentence and narration editing.

The most relevant findings of this paper revealed that 1) 58.8% of the participants from different programming backgrounds have used ChatGPT regularly, answering the question about usage of GitHub's CoPilot and ChatGPT. 2) In answer to the second question, which was about the relationship between these Generative AI tools, it says 36.4% of programmers who used ChatGPT regularly also used GitHub Copilot, whereas 86.4% used Copilot also used ChatGPT. 3) In response to the question about the increasing usage of such tools varies in different groups of developers, approximately 72.3% are those who are in the learning phase, making the largest pool of programmers use ChatGPT regularly, but only 53% of respondents were amongst the lowest category, i.e., former professional programmers. On the other hand, 26.6% of programmers used GitHub's CoPilot regularly, but 17.8% have used CoPilot the least. 4) In the answer to the last question, the researchers have estimated the usage of these tools based on programming languages (Java, JavaScript, Python, HTML/CSS, and SQL) used; the percentage of different languages used by developers varies from 62% to 65% for ChatGPT users, while it differs from developers who used GitHub CoPilot also practice such programming languages were seen 26% to 30% variation.

The researchers have utilized a Q&A-based survey conducted by StackOverflow through their platform for their research data. In contrast, we will conduct an empirical study based on open-ended interviews with IT students. Moreover, they have used different software to examine the study results. To examine qualitative data in a case study context, we will use card sorting/theme identification approaches that label themes, patterns, and connections within interviewees' responses before providing organized study results.

Method

In this chapter

4.1	Interview design and data collection	13
4.2	Interviewees	16
4.3	Data Analysis of Interviews . .	17
4.4	Demographics	19

In this research, a survey design addresses the research questions, which helped to achieve the study's outcomes after detailed interviews with university students.

4.1 Interview design and data collection

To accomplish the response to our research questions, we opted for semi-structured interviews, which assisted us in gathering meaningful insights and necessary information/data from the interviewees. An interview incorporating structure and unstructured components is known as a semi-structured interview. Although it uses a predetermined list of open-ended questions, the interviewer can explore other subjects considering the interviewee's answers. This approach ensures consistency across interviews while still enabling deeper insights. Furthermore, a pilot interview was conducted to refine and enhance the interview procedure, contributing to improvements in the subsequent interviews. The questions of the semi-structured interviews are placed under groups, as mentioned below:

Demographics:

The motivation to ask questions related to the demographics part is to learn about the students' qualifications and sample students related to the field of this research. We asked the following questions in this section:

Q.1: Where are you studying?

Q.2: Which year of your studies are you in? e.g., In which year/semester, and studies?

Programming experiences:

In this section, we asked questions related to students' programming and development experiences and the usage of forums and generative AI. It is necessary for our research that the sample of students use such platforms and large language models (LLMs) in their programming so that we can know which one they use most of the time. We asked the following questions in this section:

Q.3: Tell me about your experience in programming so far (Whether in university projects, in industry, or for self-learning purposes)?

Q.4a: Have you ever used forums, e.g. Stack Overflow for your source coding before? and if so, which ones have you used? [question to help answer the research question RQ.1]

Q.4b: Have you ever used Generative AI, e.g. ChatGPT or Copilot, for your source coding before? And if so, which tools have you used? [help to answer RQ.2]

Context of experience:

The motivation to ask questions related to the context of programming experiences is to understand the situations and contexts when students need to use such forums and AI support during their programming practices and how they perceive such in terms of reliability. We asked the following questions in this section:

Q.5: Can you please explain why and in what context, or situation you have been using forums through example(s)? [help to answer RQ.1]

Q.6: Can you please explain why and in what context, or situation you have been using generative AI through example(s)? [help to answer RQ.2]

Q.7: Tell me about reliability: do you perceive Stack Overflow answers as a reliable source code? [help to answer RQ.1]

Q.8: And what about ChatGPT: do you perceive it as reliable for programming tasks? [help to answer RQ.2]

Usefulness of ChatGPT & Stack Overflow:

The motivation to ask questions about usefulness is a way to gather information regarding how ChatGPT and Stack Overflow have been useful to students. We asked the following questions in this section:

Q.9: To what extent has ChatGPT (or Stack Overflow) been useful to you? [help to answer RQ.2]

Q.10: Could you perhaps elaborate on the ways that you have found ChatGPT (or Stack Overflow) useful? [help to answer RQ.2]

Efforts to use Forums & generative AI:

In this section, we also asked students how much time and effort they need to put in while using forums and generative AI. This information will help us determine the differences between using such platforms and large language models (LLMs). We asked the following questions in this section:

Forums:

Q.11: Tell me about the effort of using forums e.g. Stack Overflow, etc.? [help to answer RQ.1]

Q.12: Can you please give me an example of what you have to do when using a forum to get your solution? [help to answer RQ.1]

Q.13: How much of your time does that typically take? [help to answer RQ.1]

Generative AI/LLMs:

Q.14: Tell me about the effort of using generative AI e.g. ChatGPT and others? [help to answer RQ.2]

Q.15: Can you please give me an example of what you have to do when using a generative AI to get your solution? [help to answer RQ.2]

Q.16: How much of your time does that typically take? [help to answer RQ.3]

Learning while using forums and AI-support:

The motivation behind asking these questions is to understand the effects of using forums and large language models (LLMs) on students' learning of programming skills. We asked the following questions in this section:

Put yourself in the situation when you use such tools for a programming task at university...

Q.17: What do you think whether or not using forums like Stack Overflow has an effect on how well you learn to program (could you do it without)? [help to answer RQ.1]

Q.18: What do you think whether or not using Generative AI like ChatGPT and others has an effect on how well you learn to program (could you do it without)? [help to answer RQ.2]

Desires/Wishes:

To learn about students' desires and/or wishes regarding the features that are lacking in ChatGPT and Stack Overflow, we asked the following question in this section:

Q.19: Could you please clarify which features of ChatGPT (or Stack Overflow) are lacking? [help to answer RQ.3]

ChatGPT Vs. Stack Overflow:

In this section, students were asked about the situations in which they prefer using ChatGPT and Stack Overflow to facilitate a comparative analysis of these platforms and AI-based support. We asked the following questions in this section:

Q.20: In what situation do you prefer Stack Overflow (describe a situation) [help to answer RQ.1]

Q.21: In what situation do you prefer ChatGPT (describe a situation) [help to answer RQ.2]

Q.22: Do you think that ChatGPT and others can be able to substitute Stack Overflow as a Q&A platform? [help to answer RQ.3]

Q.23: Which platform do you prefer ChatGPT or Stack Overflow? [help to answer RQ.3]

4.2 Interviewees

The targeted audience for this research study is students, including internees and working students from the first to final semester of a Computer Science degree and having experience in the software development field. We interviewed 19 participants from 5 countries (Germany, Turkey, Pakistan, India, and Bangladesh), including 17 males and two females, respectively, for a broader view of our research.

Protocol:

Interviews were conducted over two months. The duration of the interviews ranged from 25 to 45 minutes, with the total duration of all 19 interviews amounting to approximately 9 hours and 41 minutes. The participants were also asked to provide their consent for the audio recording of interviews. Participants were explicitly informed that they could choose to skip or refrain from answering any interview questions that they found sensitive or that posed concerns related to their privacy.

4.3 Data Analysis of Interviews

To examine qualitative data in a case study context, T. Zimmermann et al. [Zim16] and Rune-son et al. [Run+12] recommend theme identification approaches, which label themes, patterns, and connections within interviewees' responses before providing an organized summary. In order to do so, we first transcribed all the interview recordings into text. The transcriptions of all 19 interviews consist of 287 pages or 80,847 words in total. Some words are marked with 'inaudible' during transcriptions due to a lack of sound clarity in participants' responses. Furthermore, to generate the text-based documents from audio recordings, we used an online tool, i.e., 'TurboScribe' [Tur], under the consent of participants. Also, to check the correctness of the text, we manually compare each document to its audio recordings.

After we had all the transcriptions available, we then made Excel files for every single interview we conducted and labeled all the participants' answers with the designated codes in the first phase of theme identification. More than 20 different codes were used to label the answers, such as: 'purpose of forums usage,' 'purpose of AI usage,' 'Stack Overflow is reliable,' 'ChatGPT is helpful/useful,' 'Efforts in forums/LLMs,' 'time in forums/LLMs,' 'Impact logic building,' 'effect on learning,' 'quality of answers,' 'order of usage,' 'preference Stack Overflow/AI,' and others.

Interview ID	Question ID	Quotes	Codes
17	21	Planning, understanding things and you know having a structure to things. ChatGPT helps a lot. So, situation again I would just talk about the project that I'm working on. I use ChatGPT for everything there.	Preference ChatGPT
Interview ID	Question ID	Quotes	Codes
19	8	Question: And what about ChatGPT: do you perceive it as reliable for programming tasks? Answer: Sometimes and sometimes not. It's like depending on the heuristic if it's like a problem which is used many times before you would get mostly a very good reliable answer, but if it's becoming more and more niche you will get not that good answers about it yet, but it's like the same problem in forums as well because not many people are going through these problems. So, you have to dig deeper in order to get like an understanding of it.	Quality of answers

Figure 4.1: Examples of Labeling Text/Quotes with Codes in first phase .

In the second phase, we sorted all the answers and responses of participants with the same codes into individual stacks. In the third phase, we identified themes by highlighting similar insights within participants' answers in the same stacks of cards/codes. These highlighted insights were then summarized in the results section as an outcome or finding of our research study.

Figure 4.2 below illustrates how the same codes are collected to create a Stack in the second phase, while Figure 4.3 illustrates how important insights or notes are extracted from the quotes in participants' responses during the third phase.

Interview ID	Question ID	Quotes	Codes
5	10	I mean I think for chat GPT it's easy to like learn some basic stuff of the code. Like I can just briefly ask the question and in a clear way and I can ask like can you simply give me some examples and explain that part of the code like this? It's easy. For stack overflow I also need to again like search for clear problem but sometimes it may take a bit longer time than ChatGPT and but still if it's very common or basic problem it's not a big deal.	Usefulness of Stack Overflow and ChatGPT
Interview ID	Question ID	Texts/Quote	Codes
19	9	Yeah, and so it has been useful for my extent because I had problems before that I'm not able to solve and I had pursued these goals in order to solve it because of these platforms yes. So, both platforms have been useful in order to get better understanding of contexts of programming of code. So, it helps me a lot in order to get a deeper understanding about like my topics I use.	Usefulness of Gen-AI/ ChatGPT, Usefulness of forums/ StackOverflow

Figure 4.2: Collecting the same codes to create a Stack in the second phase.

Interview ID	Question ID	Texts/Quotes	Codes	Notes
1	18	Yes, of course. I have the same opinion about generative AI as well, because if you are using generative AI even from the start, then you won't be able to program later some complex codes, because you won't be able to have a logic building in your mind for that complex problem.	AI Effect on learning, Impact logic building	Use of Gen-AIs in start might effect your learning/ logic building.
3	18	I can say that if the person is an intermediate or expert developer, he can go for the ChatGPT to depend generative AIs, because he's not going to use fully generated code for the ChatGPT. He just see the solution and then write his own code. It's own manner, which is the architect demand. But for the beginner, never say that he should go for the ChatGPT and all other forums like generative AIs, because he will use full to that situation. He immediately whenever he get (issue), he immediately go to ChatGPT and get a solution and implement that. Whether that solution is useful for his code, whether this solution, it will work on the time, but later on it will get difficulty for the architect.	Generative AI's effect on learning	Using ChatGPT as a beginners effect your learning.
Interview ID	Question ID	Texts/Quote	Codes	Notes
5	4b	For example while doing my graduation project while developing a mobile app. I don't remember the part exactly but it was related to the widgets on the app. So I got some errors and I couldn't find the solution so I just checked that error from Stack Overflow. I used it for that purpose for example.	purpose of using forums	Describing the reason for using forums. (e.g. error-handling/problem-solving)
7	5	Well, if I'm installing some software or I'm writing a code or a script, and I'm in between, and I got some issue which like I'm not able to fix. So, I always go through the forums like StackOverflow, because I know, if I came across this bug, it should be faced by so many other professionals or programmers working around the globe. So, any one of them have like logged at StackOverflow, and some people also loves to help so they add the comment like how to fix that. So in that situation I have faced and used StackOverflow a lot.	purpose of using forums	Describing the reason for using forums. (e.g. error-handling/problem-solving)

Figure 4.3: Examples of key insights or notes extracted from the text in the third phase.

4.4 Demographics

Table 4.1 summarizes the demographics of the participants, who used different forums and generative AI models for their programming practices.

ID	Participants	Usage of Forums	Usage of Generative AI
1	1	Stack Overflow, Quora	ChatGPT, Black Box AI, Gemini
2	2	Stack Overflow, Quora	ChatGPT
3	3	Stack Overflow	ChatGPT, CoPilot
4	4	Stack Overflow, Quora	ChatGPT, CoPilot
5	5	Stack Overflow, Reddit, GitHub	ChatGPT, Gemini
6	6	Stack Overflow	ChatGPT
7	7	Stack Overflow, GitHub	ChatGPT
8	8	Stack Overflow, Quora, GitHub	ChatGPT
9	9	Stack Overflow	ChatGPT
10	10	Stack Overflow, Geeks for Geeks	ChatGPT, Claude, Llama
11	11	Stack Overflow, Quora, Reddit	ChatGPT, CoPilot
12	12	Stack Overflow	ChatGPT
13	13	Stack Overflow	ChatGPT
14	14	Stack Overflow	ChatGPT
15	15	Stack Overflow	ChatGPT
16	16	Stack Overflow, Quora, Reddit, Medium	ChatGPT
17	17	Stack Overflow, Geeks for Geeks	ChatGPT
18	18	Stack Overflow	ChatGPT
19	19	Stack Overflow, Quora	Used Generative AI

Table 4.1: Table summarizes the demographics of the participants.

Results

5.1 Forums / Stack Overflow Effects on Learning

The use and effects of forums by students and their adaptation, specifically in learning, are discussed in this section. The insights mentioned below are stated by 13 out of 19 interviewees who perceive forums, like Stack Overflow, as a practical learning tool. Also, they converse about the early stages of the programming journey, when challenges were encountered in finding reliable resources, and difficulties were faced in determining their authenticity.

5.1.1 General answers force training of problem-solving skills:

During the interview sessions, 4 out of 19 interviewees reported, with some variations, the following basic scenario: they found more of a generic solution on Stack Overflow while searching for specific ones. This situation leads them to start solving problems on their own. This practice also helps to build their understanding of programming and analytical thinking. Variations of this reported mechanism include some students saying that the ability to adapt the learned knowledge to new problems is driven by the need to reflect on the solutions. Also, a more profound understanding and better ability to apply solutions to different obstacles resulted from analyzing generic answers and their adaptation to particular issues. Other students reported that they sometimes got frustrated about the forums providing general solutions, only.

“[...] it's more like generic you don't have like the concrete answer mostly for your exact problem so you have to think about it, and I think it gives you better understanding about learning stuff because you have to adapt it to your situation and your problem and for future circumstances you easily could adapt these problems then.” – participant 19

Another positive effect of forums on learning is resolving issues related to coding problems. Forums provide solutions near or close to the problem, if not precisely, which have to be modified according to the requirement.

“I think the Stack Overflow has a lot of positive effect on learning part because you have a problem you go on the forum you look for the solution for it and while looking for the solution you might find a lot of related problems as well or the problems that are closer to it but not exactly the same and then you have to because you have to manually check the reliability as well and see which problem/which solution is the one you’re looking for so while doing all this stuff you analyze deeply go through the solutions and while doing all this thing you learn a lot, because you learn new approaches you come up to see new problems and the new solutions to the problems and this helps you a lot in learning as well.” – participant 11

5.1.2 Exposure to other peoples’ minds:

Exposure to insights from senior developers. One of the interviewees also reported that forums provide exposure to insights from senior developers, whose solutions could be studied, implemented, and learned from by running and reading code line by line.

“I don’t think that forum will effect on your programming learning path. It will help you to learn more because most of the senior developers post multiple solutions and you use that solution and implement it on your own. So that will help you to learn all stuff and we use coding, you run code line by line and read all of the stuff and things. So that thing actually helps you a lot in learning path.” – participant 3

Exposure to others’ learning journey. Another interviewee reported that these platforms not only assist in coding but also provide insights into others’ learning journeys, and by looking into their journeys and following them, one can also learn.

“Then these platforms like Stack Overflow really help you because there are users who have been doing the same thing as you would like to do. And so those users like type their whole journey inside these platforms and you could like see through and also follow maybe their own, maybe in their footpaths or like combining multiple resources to make your own like learning plan.” – participant 10

5.1.3 Learning goals that were successfully supported by forums

Several students reported when asked about the effect of forums on learning, whereas 9 out of 19 interviewees used forums to learn and resolve their day-to-day programming tasks. They also reported learning to process and analyze solutions and language syntaxes and to pick and compare the right solutions for their requirements.

“If I talk about stack overflow it’s a really good tool for learning because when we search something we have a lot of different responsible answers from the different people, and different point of view from different

context, different queries, different results, so we need to try one by one each result we need to implement that, and we need to check whether is it working or not so if the result is working then okay otherwise if it's not working then it's also a learning thing [...] – participant 14

Explanations provided by forums. Also, forums have been successful in showcasing more information related to queries. For example, one of the participants reported about the following situation on forums, asking to use data structures in their programming task. It is stated that on forums, one can not only find the reasons for their usage, but the forum-based community has also tried to explain why to use them as well. For example, by gaining a point of view from the complexity of time and space, the person is exposed to more information, which will build his knowledge of programming practices.

“When you are using a forum, I already said that when you are asking for something, you are looking for something, you are searching for something definitely you got more detailed answer most of the time so when you go through that details like I mentioned if you just ask in this feature should I use stack or queue it will not only answer you will see someone is also explaining like why using stack over queue is more necessary here maybe it will explain you with the point of view of like time complexity maybe space complexity or maybe how well it will perform in real life some people also share their real life experience there so you get more insight and you get to learn more things [...] – participant 13

High amount/variety of solutions. Another participant reported that forums are a learning platform because of the extensive range of solutions provided to related queries. Also, depending on the required situation, the range could be up to 8 solutions per query compared to Generative AI, which is limited to 2-3 solutions on average.

“I think the forums because there you can find various solutions or various version of solutions to the same problem because it's coming from different people however in AI tools it will only give you maximum of two versions of a same problem and every time it will give you the same thing, because it's AI and it has a limited knowledge so if you're finding for it let's say eight versions of solution to the same problem on Stack Overflow, you'll only get maximum I believe in personal opinion you'll find maximum of two or three versions on ChatGPT, and while when you're looking to eight versions of different problem your mind opens up as well, that okay! Fine, this problem can be solved in this way as well, in this way as well, and it gives you a lot of learning as well, how you can utilizing the syntax in programming or coding, utilizing the syntax you can solve problem in different ways as well because it's all about syntax at the end [...] – participant 11

Active learning and long-term memory. One of the participants thought that ample use of these forums is active learning because searching for something for a long time and putting added effort into the brain to actively look for a solution helps to become a long-term memory.

“It has a big effect, enormous effect, because the other than that, like just learning from sources, books and applying them is kind of a passive learning and it's just sometimes memorizing. But using forums, it

becomes kind of like active learning because when you search something in forums for a long time, you kind of remember and it becomes like a long-term memory. But because you just have a more, how can I say, like put more effort and your brain actively working for that solution, so it becomes like a long-term memory [...]” – participant 8

5.1.4 Preference for Generative AI, due to time saved.

Two of the interviewees reported, with some variations, that they do not perceive forums as a learning platform but use them as a problem-solving or debugging platform, especially Stack Overflow.

“I’m talking about present. I do not use Stack Overflow to learn to program anymore because it’s much easier otherwise. So, I’m not using Stack overflow to learn anything as such.” – participant 17

“Umm...If you’re learning I would say personally I don’t see Stack Overflow as a learning platform it’s more of a problem-solving platform and that’s just a personal opinion if you’re... you know talking about Medium or Quora then that’s different you know you can use that for learning but for Stack Overflow I would say it’s more of a debugging tool like if you get problems and you want to solve those problems because obviously you learn while if you solve problems so in that sense sure you could call it a learning platform but other than that I would say you know it’s not as much of a learning platform as Quora or Medium.” – participant 6

However, they prefer to use generative AIs for learning and reading topics to understand concepts for programming. They believe that why waste a lot of time when easy ways of learning are available instead?

“Before people used to use Stack Overflow, and Quora and all these forums to study yes, but now as humans we are very used to the easy ways that we have (now), right. I don’t think so, we like to go on and on and read articles to understand a simple concept where AI can, you know summarize it and make you understand in five minutes or so. Again, it can be used but it is not used and why waste a lot of time where you can, you know get things quicker.” – participant 17

Forums speed up learning compared to not using them. Moreover, when asked students about practicing their programming without employing forums and platform support, 11 out of 19 interviewees reported that learning would be far more difficult, involving reading manuals, SDKs, and APIs in great detail, learning technical perspectives, reading codes line by line, functionalities, and how the system works.

“I think you can yeah, but it takes a lot more time you can go through an API or can go through manuals or stuff like that mostly it’s API, and you’ll take a look in the SDK or I don’t know stuff like that in order to get an understanding about it you faces.” – participant 19

However, students perceive that learning is possible without forums, but it takes longer and is less effective since they have to read books, journals, blogs, and explore links. Also, utilizing shared knowledge and practical insights, forums provide developers with precise or local answers as an alternative to books, enabling them to learn more quickly and efficiently. They also mentioned that without the support of forums, it would be highly time-consuming and require consulting with other senior students/colleagues and team members. They prefer to use them instead because, in the bigger picture, it helps them to learn more from other's mistakes and experiences.

"Can say that but it will take a lot of time. You need to go line-by-line and all the detections. Maybe you go for your seniors and other friends and colleagues to answer. So basically forum, you can say that it is also your colleagues and friends over there, which are answering your questions. So, it's same like that."
– participant 3

Also, one of the students reported another scenario: Sometimes, using these platforms, you get intrigued by something new that catches your interest, and you end up learning something new. For example, any language syntax, framework, library, etc.

"[...] I mean in general perspective I would say that while going through these forums you learn new things as well and sometimes it might happen that you get intrigued by something which catches your interest and then from there on you can go to some other like you can say Ed-tech platforms where you can find some courses to it and learn [...]" – participant 11

5.2 Reliability & Quality of Generative-AI / ChatGPT Solutions

One of the interview parts involves asking students about the reliability and quality of Generative AIs, such as ChatGPT, Gemini AI, CoPilot, and others' answers/solutions. The insights mentioned below are stated by 13 out of 19 interviewees who perceive Generative AIs/ ChatGPT's answers to be unreliable or have lower-quality solutions, depending on the situation. However, 6 out of 19 participants perceive generative AI / ChatGPT's answers as reliable.

Good for common problems not for complex situations. During the interview sessions, 6 out of 19 interviewees reported the following with some variations: They found that generative AI / ChatGPT works well for situations or problems that are small or commonly used. Otherwise, when the problems are complex and uncommon, it does not provide reasonable solutions to the related queries.

"I do not perceive ChatGPT or other generative AIs as reliable when it comes to programming it's very good for any sort of code that is very common and widely used in the past if you want those kind of codes for example finding the average of a number of a couple of numbers or like any sort of repetitive tasks or any

type of repetitive function that are over readily available and I'm pretty sure the generative AIs are also trained on those codes so that's why they are very good at those common code snippets but not complex problems that requires a lot of customizations from a human point of view.” – participant 15

Incorrect code responses. Another reported variation of this mechanism is situations where issues regarding code correctness are present. Four of the interviewees stated that they have faced problems sometimes when ChatGPT lacks correct code generation or even provides an older version of code that is not compatible with their software applications/IDEs.

“ChatGPT has a long way to come I feel. I cannot completely say that ChatGPT is reliable because it makes a lot of blunders here and there and you can (find) kind of confuse ChatGPT also. Normally when I ask like suppose I want to you know code a module and before doing the model I want to understand the right basics. So, this happened the day before yesterday only I was like doing something about the Bayesian networks and ChatGPT gave me an example and it was wrong it was incorrect, and I told ChatGPT that I don't think it is right, and it gave me a right answer after that. So, I cannot blindly believe ChatGPT. I have to be on my toes to actually you know see and understand if it's actually saying the right thing.” – participant 17

5.2.1 Switching between ChatGPT and Forums

Four of the interviewees reported that they have to switch to other alternatives when generative AI remains unable to provide the right solution according to their requirements. They stated that sometimes ChatGPT gives solutions where only the first step is reliable, not the others, so then they have to find solutions on forums.

Switching after multiple unsuccessful trials. The student states that sometimes if Generative AI is not resolving the problem, they switch to forums even during the second iteration of the query.

“Yeah, so most of the time if by the second iteration of the of GPT's answer, the problem is not being solved then it's a more likely scenario that you know it's not going to get solved and you have to go online go search some other forums like Stack Overflow or Medium. [...]” – participant 17

One of the interviewees reported that sometimes ChatGPT will not give you the right solution, even when asking for queries in simple and direct wording. Therefore, prefer to move on forums and other platforms to save time from wasting on the same thing.

“Well the first thing I would do is ask GPT again and ask in a way which is more simple in words, which are more precise, and direct and still wait for GPT to answer, and sometimes it can happen that even if you give provide the exact details, GPT might not be able to give you a precise answer, and it will waste your

time for a long time. You'd be on GPT, and you wouldn't find an answer so yeah in those scenarios then I would rather go to Stack Overflow." – participant 12

Cross-verification of ChatGPT's answers. Another interviewee reported on cross-checking of ChatGPT's solutions. The student stated that sometimes ChatGPT provides answers that are not optimum or relevant. In these scenarios would rather use solutions from Stack Overflow if found better options.

"Yeah, I would say yeah if what I'm asking (to) ChatGPT to do some design decisions in it or architectural decision or basically some sort of like a method is being used which I've never used. So, I would probably check from Stack Overflow as well, whether this method is not obsolete or basically if it is being used how/what is the complexity of a particular algorithm, and should I be using it? I would cross verify such things from Stack Overflow because sometimes (Generative) AI can give you solutions which are not the most optimum solution, and by learning from forums like StackOverflow you can cross verify (it) [...]" – participant 9

5.2.2 Project security in Generative AIs/ChatGPT

One participant also reported on ChatGPT's reliability when working on projects that emphasize security. The participant also stated that generative AI only cares about the correctness of code, not about security. Therefore, ChatGPT and others are not suitable options for such projects; instead, they prefer to use Stack Overflow for the sensitivity or urgency of the projects.

"So, for example for security if you are working on a project that emphasizes security ChatGPT is not a good solution for that because all the generative AI cares for is just the correctness of the code but not the security or anything else but if you want to make a very secure code for banking purposes for example you can definitely mention that in the post of StackOverflow that you you'll be working with banking so people who have already worked with similar projects that has emphasis on security would be able to help you out and would understand the urgency of your problem." – participant 15

5.2.3 ChatGPT answers are reliable:

Moreover, when students were asked about the reliability of ChatGPT answers, 6 out of 19 interviewees reported the following: who perceive generative AI / ChatGPT answers are reliable for programming tasks.

ChatGPT delivers perfect and better solutions. Three interviewees reported, with some variations, that they found correct and even perfect solutions for their programming-related problems on ChatGPT. They stated that sometimes, they need to provide more details about their

queries to find better solutions from ChatGPT. They also stated that ChatGPT is reliable if the problem is well-designed or explained.

“So far, I was using (it) to get more ideas, but when I use (it) for problems, it gives me like almost always correct answers. So even if it’s not working, I just like (to) give more details of the problems, then I get the better solution. So, most of the time, if ChatGPT solution is not working, it’s because I didn’t put like... data about input. Like I didn’t put enough input to describe problem. Okay. So, because it doesn’t understand problems very well, it doesn’t produce solutions as well. But most of the time, ChatGPT is reliable. If your input, if your problem is really well designed and really well explained, then it’s really reliable, I guess.” – participant 8

Code generation from ChatGPT. One of the interviewees also reported that using generative AIs/ChatGPT during its initial stages, his coding experience was not good, and he faced problems with the longer generation of code produced by ChatGPT. Also, he needed to ask again and again to get a longer version of the code. However, it is stated that the situation has changed now because ChatGPT can produce long lines of code, which is better than using Stack Overflow.

“So, my experience when I started with ChatGPT was really bad at coding, specifically say, if I want to do a very long generation of code, it then stopped. And then I have to continue. And then I have to ask it to continue again and again. But now the context length has increased and now ChatGPT can generate long lines of code and has multiple support languages, I would also say that it is much better now than using Stack Overflow. But I would also say that you need to have some experience with coding. If you don’t know coding, then using ChatGPT would really be hard.” – participant 10

Using ChatGPT for making project structures. Another participant reported that using ChatGPT resolves bugs or errors and creates the structure/skeleton of its projects. Further, it stated that it found ChatGPT more reliable for such scenarios.

“So up till now I have used ChatGPT to give me proper structure of the projects and using those structures I finished my projects and sometimes I ask for resolving particular bugs and ChatGPT has helped me in that so up till now my experience is good and I found it reliable” – participant 2

5.3 Reliability & Quality of Forums/ Stack Overflow Solutions

The following section discusses the reliability and quality of forums’ answers/solutions as perceived by students. The insights mentioned below are stated by 14 out of 19 interviewees who believe forums like Stack Overflow, Quora, Reddit, Medium, and others are reliable for programming tasks and projects. However, 5 out of 19 participants do not perceive such platforms’ answers as a reliable resource.

Prefer solutions from experienced programmers. Two interviewees reported that whenever they are looking for a solution to their problems, they prefer programmers with more experience in their respective fields. One of the students stated that his criteria for choosing reliable answers is to check the experience of those programmers.

“Yes, they are because they’ve been tested by programmers who have been in this field for a long time, they know the system in and out and the problems as well and you know just because of their experience they give answers that are reliable and functional.” – participant 12

Perceived forums reliable due to human factor. During the interview session, when asked about reliability by participants, three of the students stated that they placed forums/Stack Overflow high due to human factors. They reported that the problems and their solutions on forums are provided and solved by real-life humans, which is why they perceived forums as reliable for their programming tasks.

“Yeah, I do because Stack Overflow mostly has the information which is added by the persons that have faced the same situation as of me and the answer to those questions also have been given by the real humans. So yeah, I do rely and perceive Stack Overflow as a very reliable source.” – participant 7

Usage of Voting/ranking system leads to reliable answers. Five of the interviewees reported that they normally use Stack Overflow’s upvoting or ranking system to solve their problems. They also stated that, especially on Stack Overflow, there are multiple answers, but generally, the most upvoted answer works.

“Most of the time Stack Overflow was helping me a lot, so yes I would say it was more reliable compared to other sources and it’s because when you go to Stack Overflow and you search for something you can easily see the answers which are more up-voted, which are accepted or not even on the upvoted version people has separate thread to answer or to like polish the code more for better optimization and all that so yes Stack Overflow was very reliable on that case.” – participant 13

One of the participants also mentioned the comments attached to equally ranked answers. It is reported that comments inside these platforms describe the correctness of answers because other programmers have checked whether they are working properly.

“Yes. They are, first of all, if there are a lot of comments inside Stack Overflow or any platform search, if there are a lot of answers inside that, and they have been equally ranked, and we also have comments that are attached to those answers, and then those comments sometimes tell you if the answers are actually correct or not, because someone has already tried those solutions before you. So, I would say that if you have a long thread of answers and comments and solutions for a particular problem, then yes, Stack Overflow would be a very reliable source.” – participant 10

Community verified solutions. Two of the interviewees reported, with some variations, that they found solutions on forums reliable. They stated that these platforms have solutions verified by the community, and whenever there is a checkmark next to the question, it is a solution to your problem.

“Actually, mostly I think it’s reliable resource because like it is kind of community verified solutions, and it gives like lots of different perspectives for your problem. And most of the time you can see that it’s a common problem you’re not the only one like first facing with this.” – participant 5

Solutions depend upon the situations/contexts. Three of the participants stated that the reliability of solutions depends upon the context or situation of the problems they had. They reported that sometimes people find solutions useful to their problems, but that does not work for everyone.

“[...] So, sometimes it depends on the context like maybe that person has the same problem and he has found this solution which he provided to you on the forum as useful but it’s not useful for you or it’s not working for you. So, that’s why sometimes it depends actually. It depends on the context of the problem. So, I cannot say like it’s 100 percent reliable and you must need to use the Stack Overflow only. We have other sources as well. We can use the other sources to get our solution.” – participant 14

Encountering errors/bugs, and other issues. Two of the participating students also reported that whenever they have issues related to their programming tasks, they find forums, and especially Stack Overflow, to be quite a reliable resource. They also stated that whether the problems are related to resolving bugs or errors, dependency issues, or any other coding issues, they found Stack Overflow quite helpful than generative AIs.

“Yeah, because I have experienced this a lot if I have any dependency issue or any other bug in my code and if I and at that point when I was using Stack Overflow a lot, I mostly ended up fixing that issue with the help of Stack Overflow. So, I can say Stack Overflow is more reliable as that of ChatGPT.” – participant 7

Different problems, but Same solution. One of the participants reported tackling different situations by using forums, particularly Stack Overflow. Whether the situation concerns the need for reliable information for sensitive projects, solving higher-complexity problems, or even project development, Stack Overflow is the best option.

“Yes, for Stack Overflow it’s very... when you’re working with very sensitive project where you need reliable information, Stack Overflow is a very good solution for that, second of all if you have ample time to make a project I would suggest Stack Overflow would be a very good resource for that, and also the complexity of the problem if the higher the complexity of the problem chances are ChatGPT and other generative AIs would not be able to cater to your problem and usually Stack Overflow is a better option for a more complicated programming problems.” – participant 15

5.3.1 Solutions on forums are not reliable:

However, when further students were asked about the reliability of forums' solutions, 5 out of 19 interviewees reported with some variations, who perceived answers on these platforms as not reliable for their programming tasks.

Solutions are not general, but specific. Two of the interviewees also reported an issue related to available solutions on forums. They stated that they have to try many different answers to solve their required problem but are still unable to solve it. It is also reported that solutions on forums are not usually general but rather more specific.

“Not exactly because the most solutions (from) people, it should be some restrictive about like publishing solutions because some people publish some solutions that only work in some cases, it's not very general. And most of the time it crushed the program. And I'm just checking for the solutions who get most liked or most upvoted, but also, they can be also not working because environment is not proper or the like the files, the programs are not updated. So, it's not that reliable, but I was using it, because it was the best until ChatGPT.” – participant 8

Stack Overflow is not reliable anymore. One of the interviewees talked about the reliability of forums, mainly Stack Overflow's answers. It is reported that after Generative AI was introduced, more questions were answered using them. Therefore, the quality of answers is better, but the reliability decreases.

“I would say so in the time before generative AI, Stack Overflow was like a forum which is like very competitive and the people there are really relying on their answers and giving upwards and downwards no regarding what, but after generative AI has been coming up more and more answers are being answered by generative AI and the quality of these answers are getting better right now. So, they are not really reliable anymore. There are many answers which are garbage, and also you have some that are less in quality than beforehand. I would say it's not as reliable as it was before.” – participant 19

5.4 Effects of Generative AI & Forums on learning

Some interviewees also reported generative AI, e.g., ChatGPT, and forums, e.g., Stack Overflow's effect on learning. The insights mentioned below are stated by 4 out of 19 interviewees who experienced Generative AIs and forums affect learning programming.

Learning effect by using both. Two of the participants stated that using ChatGPT and Stack Overflow in their programming creates a learning curve or enhances learning. One of the students reported that using ChatGPT does not affect your learning but helps you better understand the solutions. It also helps you learn code syntax and approaches and increases your overall knowledge in the field of programming.

[...] So yeah, learning is as far as like learning is concerned. I would say ChatGPT does help with overall coding but the learning is not affected by that much because I try to even if I'm using ChatGPT I try to write my code as much as I can by myself so that I can learn the syntax and overall approach and I just don't copy the code into my solution and see if it is working, I wouldn't cross check it. I would cross verify the code using Manually testing and automated testing and then I would write the code by myself and not just copy paste it and I would try to understand it fully so that I would know what is actually happening in my code so I would say it has helped me to become a better engineer because by giving a good solution and then really like you can use ChatGPT to basically give you a better understanding of the solution it has given you and it will overall increase your knowledge of software programming so yeah I think ChatGPT has made me a better engineer overall.” – participant 9

Another student has also reported the effect of using generative AI and forums, especially in the early stages of programming. The student states that one should not use these platforms/generative AI often unless one has tried everything; otherwise, it will not help in logic building.

“Well, it has quite an effect for me. Well, I will give you an advice on, for example, in the start of the programming career or in the start of your programming learning, uh, you should not use Stack Overflow or ChatGPT very often unless you are stuck in the problem which you have tried everything and you're not getting a solution because it will not help you in your logic development that you will have to do without ChatGPT and generative AI. But when you are done with that part, when you are already a programmer who can build good logic/sound logic of code. So, then to speed up the development process or anything, you can use ChatGPT or Stack Overflow.” – participant 1

Time effectiveness by using both. Three of the interviewees reported, with some variations, that using ChatGPT and Stack Overflow helps them save time and speed up the process. One of the students also reported that you can learn programming without using them, but it would be a huge problem to handle and take a lot of time.

“I can do it, but it will take a lot of time maybe. Maybe in some parts I can ask for help from people, but it will also take a lot of time and effort. So, it becomes less and less efficient and it becomes a huge problem to handle it. But it can be done without forums or ChatGPT too.” – participant 8

Problem solving by using both. Two of the participants reported using forums and generative AI while solving problems related to programming tasks. One of the participants stated that he did not use ChatGPT or Stack Overflow to learn things from basics but rather to solve his problems and fix bugs or errors.

“[...] I would say that I don't go on these forums like Stack Overflow or ChatGPT to completely learn these concepts from scratch. I come to these platforms when I'm in some problems for small bugs or adding some particular functionalities. [...]” – participant 2

Not completely relying on code. One of the students reported that he did not want to rely on codes provided by generative AI and forums to complete his tasks rather than try to understand solutions from them and not copy them. He also stated that if generative AI performs these tasks better than he does, he will find himself replaced.

“I never ask ChatGPT or Stack Overflow to give me complete code because I don’t want to rely on that because that task if ChatGPT can do this task better than me then it can easily replace me, and I don’t want it. So, that’s the main reason I go to authentic documentation, authentic forums like MDN docs to learn these concepts and at the end if I have some issues, I go for ChatGPT, but I know that I am not completely copying pasting it. I understand it and then I implement it myself.” – participant 2

5.5 Effects of Generative AI /ChatGPT on Learning

The following section discusses students’ use of generative AI and their adaptation, specifically in learning. Nine out of 19 interviewees state that generative AI, like ChatGPT, Gemini AI, CoPilot, and others, is an ineffective learning tool. On the other hand, seven out of 19 students consider these generative AIs as practical support for learning programming.

Generative AI is not helpful for beginners. During the interview sessions, students were asked about the learning effect of using generative AI. Three of the participants reported that ChatGPT and other generative AI should not be used by students at the start of their programming careers. They also mentioned that the reason for refraining from these AI supports, in the beginning, is to help newcomers build their logic. One of the participants also stated that students should not get help from AI support when they start to learn programming; otherwise, it will make them habitually use generative AI.

“Yes, of course I have the same opinion about generative AI as well because, if you are using generative AI even from the start and you won’t be able to program later some complex codes, because you won’t be able to have a logic building in your mind for that complex problem.” – participant 1

Generative AI has limited knowledge. Three of the interviewees reported that ChatGPT and other large language models (LLMs) have limited knowledge. They do not provide different versions of solutions compared to Stack Overflow and other forums. Therefore, using these AI models limits the person’s learning, and it is also hard to get extra bits of information.

“Well! Most of the time what happens (is) that whatever you ask to ChatGPT, it limits the answer to that it doesn’t give you some different dimension or different scenario what might happen that if you use different style of coding or something. I would compare it like this that when you go to forum maybe 50 people, (if) not 50 maybe 10 people is answering your question so 10 people has 10 different paradigm they can explain you in 10 different ways but when you are going to use ChatGPT or generative AI it has a well-defined

answer and obviously it learn through the pattern or something some algorithm so after learning that it will try to implement or try to push you back to that answer whatever you say but in this case I would say that using ChatGPT your learning might be very limited you don't get to learn some extra things [...] – participant 13

Not entirely relying on Generative AI. It is reported by one of the students that one should first learn programming basics by using different resources, and then get help from these AI-based supports so that one should not completely rely on them.

“It's an AI teacher. So, you cannot like 100% rely on them. But if you stuck, for example, in an assignment or are looking for a solution in the project after learning the basics of any programming language, then yes, you should first focus on the basics like watching videos or meeting your colleagues or doing a course in university. If you are enrolled as a student, then you should focus on the basics of programming and then look for these generative AI options to help you. So, they are only your supplement, and you cannot 100% rely on these models.” – participant 10

Generative AI is not the best guide. One of the Interviewees reported that sometimes ChatGPT or other generative AI models are not able to properly guide you in resolving issues and problems, which affects your learning more than Stack Overflow/ forums.

“I can say yes but not as good as of Stack Overflow because ChatGPT can answer your query but it will not help you in that way like if there's any dependency issue it can help you by saying okay you may miss this library or you may have to import this thing from that library but it will not guide (you) to the best way as that of Stack Overflow so it helps you learning but the learning that you get from Stack Overflow is much more higher as that of ChatGPT [...]” – participant 7

5.5.1 Generative AI / ChatGPT is effective for learning

Moreover, when asked students about generative AI / ChatGPT's effect on learning. 7 out of 19 interviewees reported that they consider AI-based support an effective tool for learning programming.

ChatGPT / Generative AI is useful/helpful for learning:

Using ChatGPT to learn new languages. Two participants reported using ChatGPT / generative AI to learn new programming languages and frameworks. One of the students stated that it uses such support to learn the syntax and semantics of the new programming languages and can learn faster than forums.

“I would say as I said earlier that normally student what they do they go to the tutorial websites or the YouTube or the (other) things to learn the new language or new framework or new things and then they

go to the real time project but what I did I get the all help from ChatGPT and now I am successfully or you can say I am confidently work on the automation task related to the basically API automation with Java and Rest Assure.” – participant 4

Using ChatGPT to learn new concepts/topics. Two of the students stated that they used ChatGPT and other LLMs to better understand complex concepts and topics. These students also reported that ChatGPT is a very useful and effective tool for understanding programming tasks and coding.

“yeah I would say if you use GPT to understand concepts and you know learn new things it’s going to be really easy and you really solidifies your knowledge basically, because if I remember I was a year back and this was like in 2023 when GPT was not as evolved as it is now and I was learning about new concepts like Kafka topics and Kubernetes and stuff like that, and I kept asking it questions and it kept giving me answers and it kept resolving my misunderstandings and my confusions and even at that time you know I found myself to really have utilized it really properly to learn new things and new topics even complex topics like the ones I mentioned so ChatGPT is definitely like a better learning resource than these other platforms.” – participant 6

Using ChatGPT is time efficient. Three of the interviewees reported, with some variations, that they found ChatGPT, or generative AI support, time-efficient for their programming tasks. The students also stated that ChatGPT sometimes provides quick and sharp solutions.

“ChatGPT has the same effect, but I think it’s a bit more efficient because it takes less time. It’s sharper and more precise answers.” – participant 8

5.6 Efforts to get solutions/ answers in Forums/ Stack Overflow

One of the main parts of the interview is asking students about the efforts they put in when they need to get desired answers/solutions to their problems from forums like Stack Overflow, Quora, Reddit, Medium, and others. The insights mentioned below are stated by 16 out of 19 interviewees who perceive forums demand efforts. However, 3 out of 19 participants believe finding forum solutions is straightforward.

Focus on keywords/queries while searching for solutions. During the interview sessions, 4 out of 19 interviewees reported, with some variations, that whenever they search for a solution to their problems, they need to focus on the keywords related to those issues. It is also stated that writing the main keywords in the forums’ search bar helps you find your desired solutions.

“[...] When you search something you must need to focus on the keywords which you are typing, because sometime if you paste over there or if you write over there or if you describe more which is not useful, so

you will not get your accurate results so that's why I will always recommend everybody like just precisely write the keywords over there for your problem so you will get the accurate result.” – participant 14

Moreover, two of the students stated that they use precise queries while looking for solutions to their problems. The students also reported that one needs to write queries correctly while describing them on forums because it would help them get the desired answers.

“So, query it properly I mean write it down whatever you want to do. So, I'm a person who will write down everything in the google query. So, I know add/or things do not matter, but I'll write everything I'll write proper sentences. So I think make the search query better don't use redundant stuff put whatever you need and the google search engine is good enough and mostly you get the required problem in the first or second links and so I just do this I just write my problem go to the link check the topmost answer compare my problem with the problem that they are saying and if I do not get it I keep searching for it with better you know search queries.” – participant 17

Effort of choosing right/optimal solutions. Four of the participants reported that the effort in forums is to choose the correct solution according to their requirements. They also reported that sometimes they have to put extra time into finding the correct answers because there are multiple variations of answers, and you have to pick the right one that would be compatible with your tasks or projects.

“[...] So the effort in using stack overflow is just that you have a problem, you go and type you search for that problem, but then you will find loads of solutions the effort is basically to choose the right solution, is to go through all of the solution and choose the right one. The right one I mean that all of the solutions I think they give the right solution but adjusting that part of your code in your Coding file is the challenge. So that is the thing you have to be careful in choosing the solution from stack overflow, so this is the amount of effort I have to use stack overflow. So, it will be a little bit time taking.” – participant 2

Using posts to get solutions. Two of the interviewees reported that they posted their questions or problems when they did not find any related solutions on forums. One of the participants also stated that sometimes you have to post your questions when no solution exists, or the problem is unique to forums.

“I had one issue with React, so I have to get up an answer, and actually I had the problem of these that never appeared in any forum before about this kind of question here. So, I've looked up on Google, I've looked up on Stack Overflow, I've also looked up on Quora, but all of these actually didn't get any answer so this is like a worst case scenario, and then I actually have my account on Stack Overflow where I sometimes also answer I've set up the question itself and in order to get these answers I had to take I think was two days before someone answered it and the first answer wasn't like good but then sometime later another answer came which were the resolvent of my problem so it took very long, but in mostly cases I would easily get good answers within minutes.” – participant 19

Using forums is effortless:

Moreover, when asked students about their efforts to get desired solutions from forums like Stack Overflow, 3 out of 19 interviewees reported the following, with some variations: using forums is easy and effortless for them.

Using forums is not a big deal. Two of the participants reported that looking for related problems or desired solutions in forums is straightforward.

“Oh, it’s really easy. It’s not that big of a deal. You just go on any browser and just get to the website and whatever problem you have you can just write on the search bar of Stack Overflow, and you’ll get related answers to that. So, it’s really easy navigating through Stack Overflow. It’s like quite user-friendly.” – participant 1

Using up-voted answers reduces effort. One of the participants stated that using Stack Overflow is good for searching answers to related problems and tasks. The student also stated that there are several answers related to your problem, but Stack Overflow’s up-voted answers normally work.

“So how do people use Stack Overflow they just google the thing right and the Stack Overflow thing comes up. So that thing is very good you’ll get the main thing then, and there with Stack Overflow again there are many answers and as I said before there is that upvote thingy. So again, you don’t know which one actually will work out for you right, so you have multiple options there but mostly the most upvoted thing works out. I wouldn’t say it’s a lot of effort but it’s okay. It’s not the easy way to get around things but it’s fine.” – participant 17

5.7 Time to get solutions/ answers in Forums

One of the interview parts also involved asking students about the amount of time spent searching for solutions to their problems on forums such as Stack Overflow, Quora, Reddit, Medium, and others. Ten out of 19 participants reported that spending time on such forums depends on the complexity of the required problems. Nine out of 19 interviewees stated that using forums, especially Stack Overflow, involves other factors, including time.

Time depends on the complexity of the problems. During the interview sessions, 11 out of 19 interviewees reported the following, with some variations that the time spent on forums to get the desired answers depends on the complexity of the required problem. Two of the participants stated that depending on the problem they are searching for, the times vary from a minimum of 30 minutes to a maximum of an hour for testing and applying it.

“Well, for navigating through the Stack Overflow like going to it hardly takes a minute but for finding a problem and applying solution and testing it so of course it takes a variable amount of time depending on the complexity of problem. Maybe from 30 minutes to one hour depends.” – participant 1

Three of the participants also reported that the time needed to find the solution depends on the problem. It is also stated by the students that when the problem is simple or common, get the solution straightforward or in a few minutes; if the problem is too specific, it might take even days.

“It usually depends on the complexity of the problem if it’s a very common problem then it doesn’t take more than 15 to 20 minutes but if it’s a complex problem and it doesn’t have any other you could not find any other sub-reddit or sub-forums of your problem then it might take two to three days to get a proper reply of your problem.” – participant 15

One of the participants also reported that sometimes; to get the solution to your problem, you need to modify the other person’s solution according to your needs. It is also stated that the time it takes to get your desired answers on forums depends on the different scenarios.

“Best case scenario the answer is in the first comment. Worst case scenario it takes a long time. So, it depends, right, sometimes my problem will not be extremely similar to the other person’s problem so I will have to change the solutions that they are giving according to my things. So before doing that I try to find (out) if someone has the same problem as mine. So, finding that takes time typically I wouldn’t say hours and hours or at least 20 minutes of searching properly might get us to the result.” – participant 17

Posting an issue takes longer to get answered. One participant also reported the time it took to get the solution while posting the required issues on the forums. It is also stated that sometimes it took days to get replies to the posts, and sometimes, the post even got ignored if it did not provide related details.

“So, sometimes it happens that whatever you are searching for is not present in the forum that time you post the issue if you post the issue with proper description any screenshot and with all the details that needs to be answered I have seen it can be answered even within hour or so depending on how detail your question was but if you don’t provide all the necessary details then it can maybe take days or sometimes they will just get ignored and you will not get the proper answer I’m talking about the forums in that case.” – participant 13

The first step of finding a solution takes time. One of the interviewees also reported that the initial steps to finding a solution to the required problem are always time-consuming.

“Stack Overflow like for example the main thing I’ve seen with Stack Overflow is the first step finding the first step of your solution is always takes at least more than an hour for me so yeah at least an hour.” – participant 12

Finding exact solutions even takes longer time. One of the students also stated that sometimes it could take a couple of weeks to get the right solution to your bugs or errors. It is also reported that you often find a solution near to your problem but not the exact one.

“Sometimes a bug when you like using Stack Overflow, sometimes a simple bug could take you around one or two or three weeks maybe, because you cannot find the solution to your particular problem. You would find solutions to problems very near to your problem, but yeah actual solution you couldn’t find [...]” – participant 9

5.8 Efforts to get solutions/ answers in Generative AI/ChatGPT

Another central interview part involves asking students about the efforts they put in when they need to get desired answers/solutions to their problems from Generative AI tools, such as ChatGPT, Gemini, CoPilot, and others. The insights mentioned below are stated by 16 out of 19 interviewees who believe efforts in generative AI/ChatGPT are less than those in forums. However, 3 out of 19 participants reported that depending on the situation, they must put some effort into generative AI / ChatGPT.

Fast & quick responses/ solutions. During the interview sessions, 5 out of 19 interviewees reported some variations, such as whenever they search for a solution to their problems, they get fast and quick solutions. It is also stated that whatever you need from generative AI, it will provide you with solutions instantly.

“Actually, for searching for an answer or asking something it’s very like quick and fast it doesn’t take so much time to learn about something, because it gives you like immediate or instant responses.” – participant 5

Two of the interviewees also stated that generative AI/ ChatGPT gives quick responses to queries. They reported that one needs to describe its requirements, and ChatGPT will assist then.

“Well it’s very easy and handy we just need to open the website of ChatGPT and you just need to give the prompt like what you want to build and like what are you up to and what are you looking for ChatGPT will help you out in a very quickest way.” – participant 7

Easier than using forums/ Stack Overflow. 7 out of 19 participants reported that using generative AI / ChatGPT to get required solutions is much easier than using different forums and platforms, including Stack Overflow. It is also reported that to get better solutions from AI-based support, one must describe its questions or problems for better responses.

“Oh yeah, it’s much easier than if you go towards these other platforms. You can just you know write your query you can have it as extensive as you want or you could have just like a one-liner like show me how to

do this and then it's just gonna you know churn out some output, but I have found that if you give it more detail regarding your problem and you explain it more about what you want to do so it gives better results than compared to like you know if you just ask it to like generally explain something to you so yeah it's much easier it gives you the answer really instantly and you know you can arrive at a solution quite easily as compared to the other platforms.” – participant 6

Moreover, two of the students also reported that they believe these generative AI tools are easier to use than other forums because they provide specific solutions to their problems. Also, it assists in learning and building their projects.

“So, it's more easier to compare to any other platforms because my queries and answers are too specific in the ChatGPT, I mean for the generative AI. So, it's more easier to learn and build project with the help of such tools like generative AI based ChatGPT or these things.” – participant 16

Importance of writing good prompts. Seven out of 19 participants reported that using generative AI / ChatGPT to get the required solution depends on how good your prompts and questions are. The students also stated that if your prompts are proper and well-defined, then you will get your desired results easily.

“Talking strictly about ChatGPT again there are like nowadays people emphasize a lot on prompt engineering right, you have to give a proper prompt to get a proper answer. So, this is again the same thing we just have to give a proper prompt to ChatGPT so that it can understand that and give us the solutions accordingly.” – participant 17

Issues and Concerns with generative AI/ ChatGPT:

3 out of 19 participants reported the following issues while asking about the efforts for searching for their required solutions or results.

Concerns over data sensitivity. One of the students also reported that when ChatGPT does not understand the syntax of the code, you are reluctant to provide information or files consisting of sensitive data.

“[...] the main issue that I faced was, when it comes to these kinds of PDFs and all that stuff it can sometimes have sensitive data on it, and you don't want to give it to an algorithm so that's my concern with GPT.” – participant 12

Issues with understanding and training of models. One of the participants reported that the issue regarding generative AI is when you have to put more effort into getting the desired solution to the problem. The student stated that sometimes generative AI is not trained to their latest model and does not provide you with the latest solutions for your programming task. Therefore, one needs to customize these solutions according to the requirements.

“The effort that you have to... for using generative AI is that sometimes they do not give a perfectly tailor-made code what you have to do is that you have to customize the code according to your problem they do give you a whole structure but sometimes the generative AI’s are not trained to the latest model so suppose you’re actually working with a framework of the latest model chances are the ChatGPT and other generative AI’s are not trained to in that semantic of that language and might give you solutions that are a couple of generations older or versions older so that you might face problems with some sort of version error and you have to also if there is a big change between one version to another so you have to fix it by yourself so that also takes a lot of effort as well.” – participant 15

Problem regarding the correctness of responses. Two of the interviewees reported an issue regarding the responses of AI-based support. Sometimes, when a person asks common or general questions, ChatGPT might give answers unrelated to the query or topic.

“Like sometimes it’s completely going another way so it’s very obvious that it’s not related to your like answer what you are looking for, but other than that, I need to like check or double check to understand if it’s really correct or not. Like for example, for ChatGPT, sometimes when you ask something might be very common or general it can give you some other answers like related to other topics or other part of the question [...]” – participant 5

One of the students also stated that sometimes ChatGPT cannot understand the programming codes’ syntax and gives incorrect solutions to problems.

“[...] I had to include chapters (in PDF file) and GPT had already assumed that I was using this command called include chapter instead of input chapter and it was giving me solutions for included chapters at that time. I told GPT that no I’m not using this, I’m using input which it did not understand and then I had to give my entire (PDF) file to GPT and then it understood and gave me another workaround for my problem [...]” – participant 12

5.9 Time to get solutions/ answers from Generative AI/ ChatGPT

After asking students about their efforts to get desired answers from Generative AI tools, the follow-up question of the interview part also asked about the amount of time spent searching for solutions to their problems on such AI-based support, including ChatGPT and others. 13 out of 19 participants reported that spending time on these generative AI tools is less time-consuming. However, 6 out of 19 interviewees stated that using AI-based support, especially ChatGPT, for their required answers involves other factors, such as prompting and reliability, including time.

Generative AI takes less time compared to forums. During the interview sessions, 6 out of 19 interviewees reported, with some variations, that using AI-based support, including ChatGPT and others, for their programming practices is less time-consuming than forums. One

of the students also stated that getting the solutions from the forum sometimes takes days, and sometimes, it is possible that you even didn't get your solution.

"In case of ChatGPT or AI tools I would say that it can take maybe from five minutes to few hours as compared to Stack Overflow, because in Stack Overflow it can take several days as well to get the problems' solution and sometimes you won't even find the solution to the problem as well but in case of ChatGPT it can take like I think five minutes to several few hours I would say." – participant 11

One of the participants reported that generative AI is less time-consuming than other platforms because it doesn't require a lot of searches for specific solutions. In AI-based support, one does not need to consider different solutions and their comparisons.

"Oh, the time (in) AI, specifically ChatGPT, and generative AI based tools are taking less time compared to any other platform, because we don't have to search/ask lots of questions for any specific answer. We don't have to compare many solutions. We don't have to think about the multiple solutions, because we're getting the specific solution based on our query. So, obviously it is less time-consuming. And obviously you don't have to spend lots of time or lots of effort for these tools." – participant 16

Time depends upon the nature of problems. Three interviewees reported that the amount of time taken to get the desired solutions depends on the nature of the problem one is looking for. The students also stated that if you don't know where the problem lies, it might take a couple of days to find its solution.

"It's not too much I would say still depends upon the problem like if I'm asking some complex algorithm for example I'm asking it about to make an optimized Dijkstra algorithm to map, to apply it to my google map search or something then it will take quite some time as it has a lot of you know complexity so it varies depending upon the complexity of the code." – participant 1

Generative AI takes time to get solutions. Three participants reported that searching for the desired solutions using generative AI, such as ChatGPT, can be time-consuming. The students also reported that ChatGPT and others give you a solution to a problem very quickly, but sometimes, that solution is not reliable, and you have to put in even more time to get the right one.

"GPT is quite quick so yeah 15 to 30 minutes quite quick, but the issue comes when you come across a problem it will give you solutions very quickly, but it will give you also false solutions and not reliable solutions so then in that time if you include that kind of time it can take five or six hours even to find a perfect solution." – participant 12

One of the students also stated that sometimes, AI-based support provides multiple solutions, and using one according to your requirements also takes time.

“So, about the time I would say it takes also some minutes two to three minutes in order to get a good understanding about the problem, but also many cases generative AI gives you some answer not one answer but many answers so you have to elaborate from these answers which one you want to use, this is one point will take time that’s one bottleneck [...]” – participant 19

Correct prompts / Queries time taken but gives you learning. Four out of the 19 interviewees reported the importance of writing proper questions and prompts for generative AI, e.g., ChatGPT, and others. One of the students stated that writing queries takes time, but it also provides learning because you need to ask the right questions with details instead of just asking randomly.

“It takes time, but it is it has a learning curve you’re not mindlessly looking for something you’re constantly asking for questions. So yeah, if I’m giving a proper prompt, and if I’m giving a proper question, I get answers easily but if I’m being lazy and just ask weak questions, I do not get the answers. Again, this thing about writing the prompt correctly, and giving as much as details as possible is also tiring. It is time taking but it is a learning curve so it’s fine it’s acceptable.” – participant 17

5.10 Purpose of using Forums/Q&A Platforms

One part of the interview involves asking students about the reasons and purposes of using forums like Stack Overflow, Quora, Reddit, Medium, and others. The insights mentioned below are stated by 16 out of 19 interviewees who used forums when facing problems with their programming tasks and projects. However, 3 out of 19 participants are among those who use forums for learning and have different perspectives on their programming practices.

Resolving issues and problems from forums. During the interview sessions, 6 out of 19 interviewees reported, with some variations, that using forums helps them in error handling or problem-solving of their projects, tasks, and coding practices as well. The students also stated that they use forums to solve their problems, whether related to application development, video-saving issues, or even specific arrays or pointers.

“So, for example, like if I’m doing some task and, for example, I’m playing with arrays and I have to manipulate the arrays and I’m using some pointers and I have this problem like, for example, I’m facing a circular reference problem and I’m not able to figure out how to solve it. So, for example, a specific problem, which I’ve tried and tested and I’m still not able to come to a conclusion. So, I go to some forums and see how the users have approached these problems and there I get some help, and I basically try it out the other solutions of other users on that forum.” – participant 1

Searching different places for solutions. One of the students also stated that using Stack Overflow and other forums helps them find solutions from different sources.

“Yeah, so like I said most of the time whenever you’re coding, and you run into some errors or some problems, you go on Stack Overflow and then you get your answer from there basically. It’s not like it’s just the first link that you open then you get the answer. It’s more like you get the know-how of like where the solution is and then you go somewhere else, and then you go somewhere else and then finally you get your solution or whatever problem you’re trying to solve.” – participant 6

Taking forums’ guidelines to build projects. Five out of 19 participants reported that using forums like Stack Overflow is helpful in developing their programming projects. The students also stated that whenever they get stuck in their projects and there is no documentation available or they have no clue about working on a new project feature, they look up to different forums and platforms.

“Yeah, definitely for example if I were to build a new project or maybe a new feature in the existing project I would definitely, if I had no idea about that thing I needed some kind of guideline or help or some kind of starting point and at that time I would search in the Google and mostly I would go from Google to that website which are suggested in the top two or three answers and then I would read about it, so on that time mostly to get the ideas to have a new point of view in a scenario or even when I was stuck with some error I would search and I would definitely get help from this kind of forum.” – participant 13

Learning and problems-solving from forums. However, three out of 19 participants are among those who use forums not only to solve their coding issues but also to learn and understand their programming-related topics and have different perspectives on their projects. One of the interviewees stated that he used forums for self-learning and studying different programming topics, whether it was about designing and developing web-based projects or related to the deployment of application and server issues.

“Okay, as I said, I worked as a backend developer and back then, I used to self-study or self-learn for different (things), I mean different programming languages or web application development, web designing. So I used these forums, I mean Stack Overflow or Quora, Reddit, and I am very familiar with these platforms and if I can say that I was backend developer, so I have to use for any kind of a specific solution of any problem or I can say that for database design, I have to find out solutions for writing complex queries or query optimizing or perfect database designs, and also for the project deployment, any server related issue for I mean overall for these type of issue, I have to use these forums, (e.g.,) Stack Overflow and I have to find out solutions, answers and effective ways to build up projects or effective ways to write codes, minimize my codes and for this reason, I have to use these platforms.” – participant 16

Using forums for having different project perspectives. Another participant also stated that they use forums to get different perspectives or points of view for their programming tasks or projects. The student also reported that to improve further, he checks forums to see if any better and easier solution is available to perform tasks.

“In some projects, in programming, there were some parts, and I was trying to solve. But when I feel like I get stuck, I feel like maybe I will need some different perspective of the solution. Even if I can get the

solution, I'm checking whether there will be a better solution or more easy solution to improve myself.” – participant 8

5.11 Purpose of using Generative AI / LLMs

One of the other questions asked students about the reasons and purposes for using Generative AI tools, such as ChatGPT, Gemini, CoPilot, and others. The insights mentioned below are stated by 12 out of 19 interviewees who used AI-based support when facing problems in their coding and programming tasks or projects. However, 6 out of 19 participants are among those who use forums to learn and understand different concepts related to their programming practices.

Using AI support to write & improve programming codes. During the interview sessions, 7 out of 19 interviewees reported the following, with some variations: using generative AI helped them write and build their code base for their programming projects. It is also stated that using generative AI helps them organize, reuse, and even take suggestions to improve their coding for their programming projects.

“In generative AI, I am using (or) doing some codes, and I am wanted to do my code reusable, and I wanted to organize my code and sometimes my code is working fine. I just paste this code into a generative AI and ask more suggestion how can I improve that stuff, So I got that kind of suggestion from generative AI.” – participant 3

Using generative AI to build project structures. Three of the participants also reported that the reason for using AI-based support is to build their projects' skeleton or structure from scratch. It is stated by two of the students that asking generative AI to make the plan and structure for their applications saves them from writing everything related to their projects.

“So, for ChatGPT and some other AI platforms, it's like when I'm developing a code base from scratch. So, I know what I need to do. So, basically, I use Generative AI like ChatGPT to make me a base structure like skeleton structure for me so that I don't have to write each and everything by myself. So, basically, it provides me a structure, upon which I can use my skills and build upon that specific application or app or functionality or feature whichever I'm working on. So, it provides me a base structure for starting an application or some feature. So, it helps me in that context.” – participant 1

Using generative AI for testing and automation. Three of the participants also stated another reason for using generative AI support is to take help in automation testing and designing test cases for their respective coding tasks. One of the students also reported that generative AI helps a lot in writing and explaining test automation scenarios in a short amount of time.

“So for testing the code, I would say ChatGPT helps more because it helps me design test cases by which I can design and like I can test the API and I would say for my particular use case a ChatGPT is more reliable and helpful because once I give the overall code of the API to ChatGPT, so it can design a test case on its own and then I can run that test case after making a bit of changes only [...]” – participant 9

Learning and understanding different topics and concepts. Six out of 19 interviewees reported that the primary purpose of using generative AI, especially ChatGPT, is to learn and understand different topics and concepts related to the programming field, among other things. Two students also reported that using ChatGPT to better understand and summarize new topics and concepts helps them with their programming projects.

“So generative AI, I mostly use ChatGPT only and I use it for literally everything. So, say for example I have been working on this project i.e., energy price prediction for the German market, and to understand the domain knowledge I use ChatGPT because I didn’t want to keep reading everything every article that is on the internet. So, I had a very summarized way of getting all the information, [...]” – participant 17

Another participant also reported that using ChatGPT and others is helpful for learning topics and building projects. The student also stated that even if you don’t have knowledge regarding any complex topic, generative AI makes you understand better than forums in a short amount of time.

“[...] I am using ChatGPT and I found that the ChatGPT is to some extent is more useful and effective from Stack Overflow and as like if I can say to specifically like I don’t have any deep experience in data science or machine learning and I don’t have much time to learn these things from the beginner to advanced level. So, in this situation, (or) in this context, ChatGPT is helping me to build my project or to serve my purpose from the very beginner level. Though I don’t know machine learning or data science things too much, but ChatGPT is guiding me to my goals and how I can successfully create my project. So, I think ChatGPT is more effective in like this situation where I have no deep experience or I have no, I don’t know more things about any specific programming languages or specific tech stuff.” – participant 16

5.12 Preference/Order of using forums & generative AI support

One of the interview questions asked students about their preference for using Generative AI tools and forums. The insights mentioned below are stated by 5 out of 19 interviewees who described their order of using such forums and AI-based support.

Preference depends upon the situations & problems. Two of the participants reported that their preferences for using generative AI and forums depended on the nature or complexity of the problems they faced. It is stated that if the problem is relatively easy, then they prefer

ChatGPT; otherwise, for difficult or complex problems, they prefer forums like Stack Overflow and others.

“yeah I would say I was stuck on a docker problem once and I was working with environment variables in docker compose and I just couldn’t get the environment variables to be saved and I spent like an entire day on this problem using ChatGPT, and after that I asked a colleague to help me out with this and he just gave me the solution right away and he told me like that he used Stack Overflow to solve this problem so I would say if it’s like really complex problems and really deep problems you should rely on google like Stack Overflow or Medium or Quora or whatever rather than ChatGPT but if it’s like more on more easy problems you can go for GPT.” – participant 6

Preference depends upon need and selection. Two of the interviewees stated that to solve a problem that requires instant solutions and less time and effort, they prefer generative AI such as ChatGPT and others. The students also stated that sometimes, when there is a need to choose between multiple things or even fail to get a solution after multiple attempts in AI-based support, they usually prefer forums like Stack Overflow, etc.

“Yes. So, if I want to make a website, for example, so me as a web developer, when I see it, if I want to make a website, I can take help from AI models, like I can (upload) screenshot. I cannot upload my screenshot to Stack Overflow and ask for it. Like I could basically, but then I have to wait for the community members to respond to my question that I uploaded in Stack Overflow. ChatGPT does it instantly for me. So that’s one benefit. I would say (that) ChatGPT helps me, give me HTML and CSS code, which I can then manipulate. But if I cannot even solve it using ChatGPT in multiple attempts, then I would, of course, have to go through the forum for help. So ChatGPT would be my first preference to solve anything now [...]” – participant 10

Preference is forums / Stack Overflow. One of the students also reported that they prefer using Stack Overflow when there is a need to better understand a problem. It is also stated that when no solution is available while using forums, they try AI-based support to understand, but not to get the complete implementation of a problem.

“Right, mostly I would use beforehand forums in order to get a better understanding but if so, there are no answers. I use generative AI in order to get an understanding, but I will not mostly use it as a concrete problem I would elaborate. It’s more like the context and I’m getting like an abstraction of the problem. So, for example we could, if we have like a problem regarding a search algorithm for example, I would not get like the concrete problem. I would mostly use like an abstraction of it and in order how to implement it, and in order how to do so but not like give me a concrete implementation of it.” – participant 19

5.13 Will ChatGPT substitute Stack Overflow?

One of the main parts of the interview involves asking students whether ChatGPT and other large language models (LLMs) will be able to substitute Stack Overflow and similar Q&A platforms. The insights mentioned below are stated by 10 out of 19 participants who do not believe

that ChatGPT and others will be able to substitute forums like Stack Overflow. However, 9 out of 19 interviewees reported that ChatGPT and other generative AI models will substitute Stack Overflow and similar forums.

5.13.1 ChatGPT & Co. will not substitute Stack Overflow & others:

Human factor and peoples' community. 5 out of 19 participants reported that generative AI models such as ChatGPT will not be able to substitute Stack Overflow and others because such forums have reliable and verified answers from the community. The students also state that the information available on such forums is pure and authentic. The students report that ChatGPT and AI models lack human factors and cannot compete with human intelligence, whereas forums are based on the information provided by people.

“Well I don't think so I think the main difference between Stack Overflow and ChatGPT is Stack Overflow has actual humans on it, and it has problems that humans face and the solutions are also found by humans and the people that are on the community of Stack Overflow they are experienced people, what ChatGPT is doing is still learning its algo is still learning from the very same human, so it will need a lot of time and I don't think that it can replace the human brain and intelligence of Stack Overflow.” – participant 12

Generative AI relies on forums' data. Two of the interviewees reported that AI models rely on the data of Q&A platforms. They also stated that generative AI models face problems when they do not provide a solution for any new programming language; therefore, they have to rely on forums like Stack Overflow due to a lack of data.

“[...] Stack Overflow has put any data they have into the system of ChatGPT, and this circumstance makes clear that ChatGPT will be not that good in these coding problems without Stack Overflow. So, ChatGPT relies really on the answers of Stack Overflow in order to get the right heuristics for the answers and for future circumstances it will be a problem if new programming languages or new tools will be coming up, because you don't have these answers right now for that and ChatGPT will be not giving any good answers about it because they don't have this input data they have with Stack Overflow. So, Stack Overflow is a platform really necessary for ChatGPT in order to pursuit new problems in order to give also good prompts, so I think it will be not able to substitute because of the lack of data.” – participant 19

5.13.2 ChatGPT & Co. will substitute Stack Overflow & others:

Generative AI is training on same data. Two of the participants stated that ChatGPT and other AI models will be able to substitute forums such as Stack Overflow, as they will have more refined and large data available. It is also stated by one of the students that these AI models are training on the same data as provided on the forums, so they will be able to substitute such forums.

“So, I’ve been using ChatGPT since it was in beta and it was it improved a lot since then, and also I believe that the newer versions of all the generative AI’s are using all the posts of Stack Overflow and other GitHub projects, so eventually I believe that there will be a time in the future where it will be able to at least catch up to Stack Overflow’s resources, because it will basically train on the same resources as the Stack Overflow posts and others.” – participant 15

AI models are learning from humans. One of the students also reported that generative AI models will be able to substitute Q&A platforms like Stack Overflow, Quora, Reddit, and others because such models are learning from humans day by day. The student also stated that these generative AI models are becoming more powerful because they are feeding human knowledge into their memory.

“Yeah as everybody knows ChatGPT is the most powerful AI generative tool, and it’s in the coming year and it will be substitute Stack Overflow and other tools like Stack Overflow, because it’s really powerful and it’s learning day by day from the humans and it has humans’ knowledge, it’s feeding in its memory. So, I think it’s day by day getting more and more powerful so definitely it can be able to substitute in the coming years.” – participant 14

Humans prefer feasible options. Another student also stated that ChatGPT will substitute other forums as it improves. Also, humans do not like to have difficult ways of doing work when feasible options are available.

“As time passes ChatGPT will get better. It’s already very, very good but as time passes it will get better and obviously it will substitute Stack Overflow, because as humans also we are getting extremely lazy to do anything. We don’t like tedious work and when we have a very feasible option in our hands, I don’t think so any one of us would like to go and do anything that’s difficult.” – participant 17

5.14 Lacking features in ChatGPT and/or Stack Overflow

One of the main interview questions is asking participants about the features lacking in ChatGPT and/or Stack Overflow. The insights mentioned below are stated by 10 out of 19 interviewees who described features that are lacking in both. Moreover, 9 out of 19 participants discussed features lacking in ChatGPT or Stack Overflow.

5.14.1 Features lacking in ChatGPT:

17 out of 19 participants are those who talked about the features that are lacking in ChatGPT.

Reliability and verification of answers. 7 out of 19 participants reported that the feature lacking the most in ChatGPT is regarding the reliability and verification of responses. The students have reported that sometimes they need to check the reliability of the answers, but ChatGPT does not provide the references. Also, sometimes, they need to verify or cross-check the answers because ChatGPT also produces incorrect responses.

“[...] In ChatGPT, the user interface is simple, but what I don’t like in ChatGPT is the answers. Sometimes I’m trying to get reference for the answer because I want to check whether it’s reliable or not, but it’s not providing any references. And sometimes it can confuse, like it needs to learn more and more, it will become better, but sometimes it’s confused answers and it can produce wrong answers. You have to do a double check sometimes.” – participant 8

Other students also reported a lack of reliability in ChatGPT’s answers. It is stated that ChatGPT generates solutions that don’t exist on the Internet.

“In GPT, I would (say) just by giving solutions or by giving suggestions that actually exist on the internet. Recently, I wanted to do some research on a study, and I asked GPT to show me some published papers on this topic. It did show me those papers but those papers were not actually existed on the internet, okay. So, it’s quite problematic because you rely on these tools at times and then it’s not good so I would rather go to a forum like google scholars and search for published study and get an actual paper there.” – participant 12

Addition of an editor/IDE into ChatGPT. Four out of 19 participants stated that the feature lacking in ChatGPT is an Integrated Development Tool (IDE) or a code editor tool. The students also stated that sometimes, when using code or projects from ChatGPT, one has to test whether it is running correctly before using it.

“[...] and another thing would be I think because it provides codes and programming stuff or technical stuff as well, so I think if I would say because sometimes it provides you a code which has a lot of different libraries and stuff so I think if an editor is included in it that would be great as well so that when you copy paste the code on your environment you have to may sometimes face a lot of errors, because of the dependencies and this puts you in another loop of finding a problem or fix an error which was caused to a solution that you were looking for to another problem of yours, so I think these are the features that could be included.” – participant 11

ChatGPT lacks data. Three of the participants stated that data is another feature lacking in ChatGPT. The students stated that ChatGPT would improve if more data were provided. One of the interviewees also stated that ChatGPT should update its data to the current time so that relevant solutions to the problems can be found.

“Well, for Stack Overflow, I cannot say much because these days/years, I am not using it much as compared to some, generative AI models like ChatGPT and Blackbox. So, but for ChatGPT, I can say that it can be better if you are feeding it a lot of data. So, when a new model comes, it’s given a lot of data. So, I think it would be a tremendous amount of improvement over the last model of which is GPT four. So, it depends all upon the data.” – participant 1

5.14.2 Features lacking in Stack Overflow:

11 out of 19 participants are those who talked about the features that are lacking in ChatGPT.

Addition of an AI for immediate responses. 5 out of 19 interviewees reported that Stack Overflow lacks quick responses to queries. The students also stated that to get a solution on Stack Overflow, one needs to provide a lot of details and have to wait so long for required responses sometimes.

“I will start with Stack Overflow as I said when you are asking something in the forum like Stack Overflow you have to give a lot of details to get a proper answer and a quick answer and in some cases it’s not that much simultaneous because you ask something maybe after one hour or two hours, some people will answer that and then after that two hour maybe you have already solved your issue, or maybe sometimes this happens that after two hours you are busy with something else and you forgot to check on the answer. So, the timing or responsiveness and continuity of that is lacking in Stack Overflow, but again it can depend on your luck maybe you asked a question and someone can even answer it within a minute or something or maybe you don’t need to even ask you just search it and the answer was there so then it doesn’t require too much time so on that case it will not lack, it but if you see in general then yes, this feature I would say is absent in Stack Overflow [...]” – participant 13

Three of the participants also stated that Stack Overflow lacks quick response time; therefore, it should have developed its own generative AI or Chatbot.

“As for Stack Overflow, it’s a very old platform and it is just text-based so there’s a lot of things that can be done like you know adding a small chatbot to make sure that like you know to get proper responses [...]” – participant 17

“Stack Overflow really, I think, needs to develop their own AI because ChatGPT and Claude is like really going far in all of the coding problems, because at the end of the day, Stack Overflow used to solve problems with a community.” – participant 10

User Interface (UI) is lacking in Stack Overflow. Two of the students reported that another feature that is lacking in Stack Overflow is its user interface (UI). The students stated that sometimes it is difficult and distracting to understand solutions and their differences and to find sources of different solutions.

“First of all, the thing I don’t like about ChatGPT, and forums is the user interface, because it’s kind of, I mean, in ChatGPT it’s kind of good because it’s simple, but Stack Overflow is kind of distracting and complex rather than it should be simple or more sharp. So, it’s also like lacking some sources on the problems or solutions. So, it becomes more complex, the references, the people who publish the solution, it’s indifference at different parts. It’s kind of hard to understand, what is that? What is this? [...]” – participant 8

5.15 Usefulness of ChatGPT & Stack Overflow

One of the other interview parts involves asking participants about the usefulness of ChatGPT and Stack Overflow. The insights mentioned below are stated by 13 out of 19 interviewees who described ChatGPT as useful for their programming tasks. Moreover, 6 out of 19 participants believed in the usefulness of Stack Overflow as well.

5.15.1 Usefulness of ChatGPT:

13 out of 19 students reported that ChatGPT is beneficial for their daily tasks, including learning concepts, planning projects, gathering information, and others.

ChatGPT saves time. Two of the participants stated that ChatGPT is quite useful because it saves time. One of the students stated that before ChatGPT, we needed to use forums like Stack Overflow for different programming tasks. Now, we use ChatGPT for such tasks, which saves time and increases productivity.

“So, they have been useful as in they saved a lot of my time when I got stuck at something. For example, initially I got errors. I have to look at Stack Overflow and websites like that manually. And then that took a lot of my time just debugging the code. But now ChatGPT does it for me. So, it’s very useful in increasing my productivity. And also, sometimes there are solutions which are not even in Stack Overflow and are very simple to solve for the AI models. And that is also learning for me then.” – participant 10

Learning and understanding concepts. Four out of 19 students stated, with some variations, that ChatGPT is useful for learning programming concepts and the code syntaxes of different languages.

“[...] I would say for ChatGPT, I currently am trying to make a weather application so for that I have to learn something about APIs. So, I’m asking ChatGPT to briefly and clearly explain (to) me API concepts, and how to call that API into my front end. So, these days ChatGPT is helping me in this scenario and to be honest using ChatGPT I have played so many concepts. So, yeah this was the example for ChatGPT.” – participant 2

Quick and specific solutions. Three of the participants reported that ChatGPT is quite useful in providing fast solutions, mainly to common problems. It has also been reported that ChatGPT gives solutions to specific problems.

“Yes, some of the ways that I’ve found ChatGPT is useful is when I need a very quick solution to a very common problem [...]” – participant 15

5.15.2 Usefulness of Stack Overflow:

7 out of 19 participants were among those who believe Stack Overflow is useful in resolving bugs and issues, cross-verification of answers, having different perspectives of a solution, and others.

Problem solving and error handling. Five out of 19 participants reported using forums, especially Stack Overflow, to solve complex tasks and resolve errors for their programming projects. One student also reported that sometimes ChatGPT wastes time in resolving errors, so it's easier to use Stack Overflow than ChatGPT.

"[...] I still use Stack Overflow for the error messages that I get. I sometimes feel like ChatGPT tells me random things to do and it wastes a lot of time, but whenever I go to Stack Overflow with an error it gets solved easier than that." – participant 17

Cross verification of solutions. Two of the interviewees stated that they use Stack Overflow to check and verify their solutions, which they get from ChatGPT. A student also stated that one of the advantages of using Stack Overflow is that your answers always get checked by other people, whether they're correct or not.

"[...] I would first use ChatGPT for most of my day-to-day tasks and if something like a design decision is involved, so I would use Stack Overflow for such things to cross verify my solution Which I've gotten from chat GPT. So, yeah, these tools have helped me a lot to learn and grow as a software engineer," – participant 9

Using for having different perspectives of solutions. One of the participants reported using Stack Overflow to solve errors and find different points of view on solutions for their programming tasks.

"[...] I would first use ChatGPT for most of my day-to-day tasks and if something like a design decision is involved, so I would use Stack Overflow for such things to cross verify my solution Which I've gotten from chat GPT. So, yeah, these tools have helped me a lot to learn and grow as a software engineer," – participant 5

5.16 ChatGPT is the Preference

One of the interview questions involves asking students about the situations where they prefer ChatGPT. The insights mentioned below are stated by several interviewees, who describe different situations where they prefer ChatGPT to perform their programming tasks.

Prefer in making projects' architecture/structure. During the interview sessions, 6 out of 19 interviewees reported, with some variations, that they prefer ChatGPT when they need to develop their project structure. The participants also reported that they prefer ChatGPT when they require groundwork or planning on new tasks or projects.

"Planning, understanding things and you know having a structure to things. ChatGPT helps a lot." – participant 17

ChatGPT provide assistance & learning. Four out of 19 participants stated that they prefer ChatGPT for learning new topics and concepts related to programming, and also used it to get help in developing project base. It is also stated by one of the students who prefers ChatGPT to learn new programming languages as well.

"ChatGPT can help me provide the starting of an architecture, the starting of a new learning of a programming language or like in learning it's really helpful [...]" – participant 1

Prefer ChatGPT to save time. Three out of 19 students reported that they prefer ChatGPT because it saves a lot of their time. The students stated that they prefer ChatGPT when they do not have much time to complete their tasks. Also, ChatGPT saves time when searching for solutions to problems and understanding different concepts compared to forums, as stated by the students.

"[...] I would prefer ChatGPT as it saves a lot of time as compared to stack overflow, it has helped me in different scenarios when I asked it to teach me about core concepts and core skills in that cases ChatGPT has helped me [...]" – participant 2

Quick responses and answers. Three interviewees reported that they prefer ChatGPT when they require immediate responses or solutions to their problems. Students also stated that they prefer ChatGPT to quickly fix the errors in their codes or to prepare tasks/projects in less time.

"I would only prefer ChatGPT when I need the answer very fast, and I exactly know I need this much of knowledge maybe I'm only stuck with a simple error or I only stuck with the error line and I need to present my code somewhere very fast then I would use ChatGPT because when I ask ChatGPT, okay this is my code or this is the snippet of my code, and this is the error I'm having, then ChatGPT will give me answer pretty fast and I can interact with it, so on that case I will prefer ChatGPT [...]" – participant 13

Prefer ChatGPT for different programming tasks. Two of the students also reported their preferences for ChatGPT in different situations. It is reported by the students that apart from debugging, they prefer to use ChatGPT for programming tasks related to repetition and automation.

“[...] for example for the repetition task if I want to do something repetitively, I would just give one example to the ChatGPT, and I would ask him to do all the rest. For example, I would say let’s say I have a file, a config file where there is a key of IDs which are there in DB (Database), so I can ask ChatGPT to convict. I can pass one config file to it and I would ask ChatGPT to provide me with 200 more such files or maybe provide a script or Python script for it which generates 200 more files of it and every file should have for example let’s say five IDs from the list so if I have 200 IDs it will provide me either with a script which can generate 100, or maybe I think 40 files for it, or maybe provide a script that can do this task automated or automate this task so for these kind of repetition or some task which requires look up for information I would go for ChatGPT.” – participant 11

5.17 Preference is Stack Overflow

Another interview question involves asking participants about the situations where they prefer Stack Overflow. The insights mentioned below are stated by several students who reported different scenarios in which they prefer Stack Overflow for their programming-related tasks and projects.

Prefer Stack Overflow for Error handling. During the interview sessions, 6 out of 19 interviewees reported the following scenario when they prefer to use Stack Overflow, with some variations. The students also stated that they prefer Stack Overflow when resolving issues and handling bugs/errors in their projects because it has various solutions from different people, and you get your solutions according to your requirements.

“[...] if you stuck in your code snippet or if you have some bugs or errors found in your prototype on your programming code, so you can go to the Stack Overflow directly, because there are many solutions from the many people they’re already pasted over there, and you can just get that solution one by one you can implement on your code and check it, [...]” – participant 14

Acquiring knowledge from Stack Overflow. 4 out of 19 participants stated that they prefer Stack Overflow, whether they need to learn any programming language, acquire deep knowledge, or gather specific information related to programming practices.

“Yeah, definitely if I have to choose Stack Overflow then, I would prefer when I have enough time in my hand and I want to go to the in-depth, I want to acquire the in-depth knowledge of something, then I would prefer Stack Overflow any day [...]” – participant 13

Prefer for different perspectives & verified solutions. Four out of 19 students reported that they prefer Stack Overflow when they need different perspectives, ideas, and opinions to solve their problems. The students also reported that they prefer Stack Overflow when a verified solution is required or when the solutions provided by the generative AI need to be verified.

“Like especially if I need answer for an error on my code, I prefer Stack Overflow or if I need like some different perspectives or comments verified solutions, I go for the Stack Overflow [...]” – participant 5

Prefer to move on Stack Overflow from ChatGPT. Two of the participants stated that they prefer to move on to Stack Overflow when they are not able to use ChatGPT. The students stated that sometimes ChatGPT is not able to resolve problems even after a couple of attempts, and sometimes, when the server is down or you don't have a subscription, they prefer to move on to Stack Overflow.

“Yeah, so after about like the first or second try at ChatGPT, and you know, you don't get your issue resolved, I move on to Stack Overflow. So, I find it you know it's much easier to just look for the problem yourself and you know find the solution yourself, rather than relying on ChatGPT and just wasting your time [...]” – participant 6

Prefer Stack Overflow when time is available. Two of the participants stated that they prefer to use Stack Overflow when they have a lot of time available and the problem is quite difficult to solve.

“(Prefer Stack Overflow) when I have a lot of time and topic, or the problem is quite complicated (or) it's complex.” – participant 12

5.18 Usefulness of ChatGPT

One of the interview parts involves asking students about the usefulness of ChatGPT. The insights mentioned below are stated by 7 out of 19 interviewees, who elaborate on the ways in which they have found ChatGPT useful for their programming tasks and projects.

Easy to search and ask queries. During the interview sessions, two of the interviewees reported, with some variations, that they found ChatGPT useful while asking queries and searching about topics compared to forums. One of the students also reported that ChatGPT can understand our queries better than traditional platforms. Another student stated that using ChatGPT to plan things accordingly is easy because you do not have to search a lot and go deep, unlike Stack Overflow.

“[...] I can say that the query or natural language query in traditional way or Google search engine or Stack Overflow or Quora or Medium, (in) these platforms, we have to search by specific keywords, phrases and our queries should be based on particular sectors, particular languages, datasets, etc. But in ChatGPT, we can ask anything, and our questions are more easy and more natural as like we used as human beings. This is the simplest way, and we can just ask our question to ChatGPT, and ChatGPT understand our purpose more than these other platforms and we don't have to memorize keywords, wouldn't have to calculate the phrases, what should I ask to the Google.” – participant 16

Useful for Information gathering. Two of the participants stated how useful ChatGPT is for them. The students reported that they can gather information and get solutions to their programming problems from ChatGPT without wasting a lot of time.

“Well, ChatGPT is very much useful to me right now as being a master student, because without wasting a lot of time you can easily get the solution or get information that you’re looking for. So, this is very at this point I can say ChatGPT is very useful.” – participant 7

From Answers to complete projects, ChatGPT delivers. One of the students reported that using ChatGPT is helpful in different ways compared to Stack Overflow. It helps you provide specific solutions and answers without comparing them to others. Moreover, as the student stated, ChatGPT is also useful in providing the whole project and delivering the complete code snippets of such projects.

“[...] the answers we got from ChatGPT are too much specific, so we don’t have to search over and over, put into tasks over and over as like we do in Google or any other platforms and we don’t have to compare lots of solutions which would be perfect for my problem and which will be easier to understand. In that case, ChatGPT provides specific solutions and also, I can optimize/minimize that solutions by providing my criteria. And another extent is about I can say the solution. Like ChatGPT can provide the whole project based on my query and can deliver full code snippet of a project based on my query. So, it’s of course, it’s a nice thing. And compared to any other platform, we just have to ask a lot of questions for specific problems, part by part. But in ChatGPT, if I can deliver my query perfectly, then it can provide me with the full project, full code snippet from beginning to end [...]” – participant 16

Useful for Problem solving /Error handling. Two of the participants also reported finding ChatGPT useful for problem-solving and fixing bugs or errors. One of the students stated that when programming problems are not complex, you can use ChatGPT for help. Furthermore, when there are too many errors to solve, as the student reported, you can also use ChatGPT to resolve or fix such errors.

“Yes! So, what happens is there are extensions inside Visual Studio Code that help us, like there’s one extension called prettify, which checks the syntax and makes the code beautiful. But what happens is sometimes the syntax errors are too many for the prettify to solve. Then I’ll just copy the whole code and paste it inside ChatGPT, and I’ll just ask it to debug or just fix the syntax and it would like solve it for me really fast.” – participant 10

5.19 Usefulness of Stack Overflow

One of the interview parts involves asking students about the usefulness of Stack Overflow. The insights mentioned below are stated by 4 out of 19 interviewees who described how Stack Overflow is useful for their programming tasks and projects.

Stack Overflow is useful when ChatGPT fails. Another student reported that Stack Overflow is useful when ChatGPT cannot provide a solution. The same student stated that sometimes, when asking for a solution from ChatGPT, it does not deliver the required solution; instead, it gives the same answer repeatedly. Then, the student prefers to use Stack Overflow to get the desired solutions for programming tasks.

“[...] like I’m doing some kind of work in developing some books system for my company and I’m stuck in some kind of phase that there is some API which is not getting hit. So I’m going into the ChatGPT and also tell that in this particular part I have an error, where ChatGPT giving me that code again and again and repeating that stuff again and I can (say) it’s very irritating, and then I certainly go to Stack Overflow and according to that stuff, another person already asked the question. [...] – participant 3

Useful for Different perspectives /POVs. One of the participants also stated that Stack Overflow is useful because it offers different solutions to problems from different perspectives. A student further stated that Stack Overflow not only provides an answer but also gives explanations and different points of view so that you will get a better understanding of any solution.

“Yes, like I said when I search for something in Stack Overflow, it doesn’t only answer the exact... I mean only the answer then it also explains like okay you are using this, this, this in the coding and why because, if you use for example if it’s about optimizing a code it would give you some graphical representation in the web page or something, or sometimes it explains like okay when using stack is better than the queue in that case, and they will give you some example like for this reason or sometimes they would calculate the time complexity, space complexity and this is how you get more insight about the code rather than just copy pasting.” – participant 13

Useful for resolving issues and problems. During the interview sessions, three interviewees reported with some variations that they found Stack Overflow useful while looking for solutions to their programming-related problems. One of the students reported that when you have a problem, you will mostly find reliable solutions from Stack Overflow because other people have had a similar issue, and the same problem has occurred multiple times before. One of the students also stated that if you are not able to solve problems through the available documentation, then you can get the relevant information by using Stack Overflow.

“Yes, I guess because it (Stack Overflow) has a lot of information by the experts and it guides you in the best way and it also helps you whenever you face an issue and you’re not able to fix that problem, fix that error from the documentation of that programming language, so you can easily hop up to Stack Overflow and you can easily have some information or relevant information that can really help you to fix that problem.” – participant 7

Discussion

In this chapter

6.1	RQ1: When do students use forums like Stack Overflow, during programming tasks?	59
6.2	RQ2: When do students use AI assistance like ChatGPT, during programming tasks?	60
6.3	RQ3: How do they perceive both technologies in comparison? .	60
6.4	Comparison of Results to Related Work	62

In this chapter, we will discuss our findings about our research questions and comparison to related work.

6.1 RQ1: When do students use forums like Stack Overflow, during programming tasks?

Our findings show several occasions where students use forums like Stack Overflow, Quora, Reddit, Medium, and others while doing their programming tasks and projects. The instance that has mostly occurred in our findings is learning, whether it is about learning different programming languages and their syntaxes, learning problem-solving skills like error handling and resolving issues, or learning and understanding different programming topics and concepts.

Another occurrence of students using forums like Stack Overflow while performing their programming tasks is the cross-verification of solutions provided by AI-based support like ChatGPT and others. Moreover, when AI-based support fails to provide desired solutions to students' queries even after a couple of attempts, they prefer to use forums like Stack Overflow.

Furthermore, the instance where students use forums such as Stack Overflow is when they require a different perspective or points of view on a solution. Also, when they need to find a solution to a complex problem while performing their tasks, as well as when seeking help or guidelines for their programming projects. The other main instance when students use forums like Stack Overflow is when they have more time available to use such forums or they need to acquire in-depth knowledge and get familiar with the insights from senior developers regarding their programming journey.

6.2 RQ2: When do students use AI assistance like ChatGPT, during programming tasks?

Our findings also highlight the events when students used AI-based support such as ChatGPT, Gemini, CoPilot, Claude, Llama, and others for their programming practices. Therefore, one of the instances where students use these AI supports mostly is to save time, where they get quick solutions to their problems, queries, and searches without spending much time and effort. Another highlighted finding of using AI assistance like ChatGPT between students during their programming tasks, is to build up their project structures, or even to build the whole programming projects as well.

Moreover, one of the instances discovered by our findings, when students used generative AI models while performing their programming tasks is about learning and understanding topics and gathering relevant information for their tasks. Furthermore, one of the other scenarios when students use ChatGPT, and other large language models (LLMs) is, when they need to perform different tasks related to automation, and repetition for their programming projects. Even, to write different programming codes as well. According to our research findings, another instance where students use AI-based support like ChatGPT is when they need to find a solution to an easier or common problem.

6.3 RQ3: How do they perceive both technologies in comparison?

The findings of our study also showcase how students perceive both technologies i.e., forums such as Stack Overflow, etc., and AI-based support like ChatGPT and others in comparison.

Forums/Stack Overflow:

Our findings demonstrate that the students perceive forums such as Stack Overflow, Quora, Reddit, Medium, and others as reliable platforms for their programming practices. Students perceive such forums are reliable because they contain human aspects, which consist of a huge community of developers and programmers available online. Moreover, another reason for perceiving forums as being reliable by students is that such forums have their up-voting system of solutions/answers, which leads students to more reliable solutions to implement in their tasks or projects.

Another finding of our research study is about forums like Stack Overflow where students perceive such platforms as a learning tool for their programming concepts and topics. Students perceive forums as a learning tool because such forums provide solutions along with explanations from different perspectives and points of views.

Furthermore, it is also revealed by our findings that students perceive forums like Stack Overflow as a problem-solving platform for their programming tasks and projects as well. Students perceive particularly Stack Overflow as a problem-solving platform because it assists in day-to-day error-handling, debugging, and fixing issues related to their tasks and projects.

Generative AI / ChatGPT:

Our research also discloses how students perceive generative AI tools like ChatGPT, Gemini, CoPilot, Claude, Llama, and others for their programming practices in comparison to forums. Students do not completely rely on AI-based support as they perceive such tools have limited knowledge. Therefore, it is not helpful or useful especially for beginners as far as programming is concerned. Also, they do not perceive ChatGPT and other large language models (LLMs) as the best guide for learning as well.

Moreover, another answer to this research question is about reliability where students do not perceive generative AI's responses as reliable in contrast to forums. Students perceive AI tools sometimes generate incorrect code responses to their queries and problems and fail to provide the right solutions as well. Therefore, they were compelled to use forums to cross-verify answers provided by generative AI tools. Another key finding highlights that students often perceive AI-based support as less reliable than online forums, primarily due to concerns about the security of their projects. This perception stems from the need to disclose sensitive project details when interacting with generative AI tools to resolve technical issues, which raises privacy and confidentiality concerns.

Furthermore, students perceive generative AI tools as time efficient and effortless, because they get their solutions or answers to required problems quickly as compared to forums like Stack Overflow and others.

6.4 Comparison of Results to Related Work

Based on our research findings, we can confirm the results of a related work study [Gar+23] that students use ChatGPT over Stack Overflow, due to the inconsistency of user queries. However, we cannot confirm overall preferences for using such technologies, because our sample size consists of a single field of students, as well as information scent, because our findings suggest students mixed variations of claim while finding pertinent information towards ChatGPT.

Also, we confirm the insights of other studies [Liu+23], that ChatGPT is fast in its task completion, and provides better solutions and quality of code when assisting with algorithmic and library-related activities, while Stack Overflow is better for debugging tasks. On the other hand, we confirm that ChatGPT is fast in code generation, while Stack Overflow is better in explicit exception handling.

We also confirm the insights of other studies [CA24], that students make good use of ChatGPT without having formal training, but some students struggle with prompting queries properly to get optimal solutions. We also confirm that students use ChatGPT for learning purposes, but not all of them. However, we cannot confirm other verdicts from this related work study, due to having different aspects of research questions, such as students are unsure that such technologies will lessen the demand of programmers, and integration of ChatGPT exercises in courses will be beneficial. Also, students generally have favorable judgments about these resources and how they are used in the classroom.

Moreover, in response to the results of another study of related work [Kab+24], we confirm that as compared to human responses, ChatGPT has more inaccurate and inconsistent responses, but are detailed and variety of topics in its responses. We can also confirm that ChatGPT rarely makes syntax errors as well. Also, we confirmed that depending on the situation students prefer to choose Stack Overflows' human responses over ChatGPT. However, we cannot confirm other results of this study, such as ChatGPT appealing sentiments, missing out incorrect ChatGPT responses, and able to accurately distinguish between ChatGPT and Stack Overflow responses, because it is out of our research study domain.

We also confirm the insights of other studies [BMS21], that Stack Overflow takes a longer time to respond to posted queries. We cannot confirm that Stack Overflow is not the most apparent place to look for assistance. Hence, it is an apparent place to look for assistance when it comes to programming tasks as claimed by many interviewees in our research study. Also, we cannot confirm that students couldn't get project-specific solutions from Stack Overflow. However, we cannot confirm or deny other results of the study, due to out of our research domain such as, barrier of time-limitation, stay in comfort zone, minimal or lack of self-confidants, etc., in response to participate/contribute on Stack Overflow and GitHub.

Furthermore, we confirm the insights from this study [Men23], that to get an enhanced solutions from generative AI such as GitHub CoPilot, students need to attempt couple of prompts. Also, we confirm that prompts should be written more precisely, along with its instructions and standard keywords. However, the result regrading applications to learn how to collect user input to achieve accuracy, is not part of our research domain. Therefore, we cannot confirm, nor deny that fact.

Also, we can confirm that students are using generative AI like ChatGPT more than other tools. We also confirm that, especially beginners in the field of programming are using them more often than seniors or former professional developers, in response to the results of another study of related work [PK24]. However, we cannot confirm or deny the facts which is not part of our research domain, such that the relationship between generative AI tools like ChatGPT & GitHub CoPilot used by programmers regularly, estimation of usage of such tools in terms of different programming languages used such as: Java, JavaScript, Python, HTML/CSS, and SQL.

Conclusion and Future Work

In this chapter

7.1	Conclusion	65
7.2	Future Work	66

7.1 Conclusion

In this research, we performed a qualitative interview study to address questions such as: when students use forums like Stack Overflow, etc., as well as generative AI tools like ChatGPT and others, during their programming tasks. We further investigate how students perceive both technologies in comparison. During our research, we gained information regarding the various occasions when students use such tools while working on their programming projects. Although some of them are known and documented in related work, several are new and provide a better view on the current situation.

The findings of our research indicate that students use forums during programming tasks on several occurrences, including learning different programming topics and concepts, solving problems and technical issues, cross-verifying answers, and gaining diverse perspectives on possible solutions. Moreover, our study revealed that students use AI-based support during their programming tasks primarily to save time, assist in building project structures, facilitate testing and automation tasks, and obtain solutions to simpler or commonly encountered problems.

Furthermore, when it comes to the comparison of both technologies our research study revealed that students perceive Stack Overflow as more reliable than ChatGPT due to the human factor involved, and a better learning platform compared to ChatGPT as well. Also, on

one hand, students perceive ChatGPT has limited knowledge, less reliable solutions at times, and less security for their data and projects demanding sensitivity, but on the other hand, ChatGPT is time efficient and effortless to get solutions to problems as compared to Stack Overflow.

7.2 Future Work

Our study discovered several interesting insights regarding the use and comparison of forums and generative AI tools. Therefore, a comparison to further investigate one generative AI / large language model (LLM) to another, would be interesting research we have as a future work. For example, as we have more and more new generative AI/LLMs available. So, a comparison between ChatGPT and DeepSeek in terms of programming tasks, to compare the quality and correctness of code generation, as well as the reliability of solutions, would be another interesting research to compare both generative AI/LLMs' performances.

List of Figures

4.1	Examples of Labeling Text/Quotes with Codes in first phase	17
4.2	Collecting the same codes to create a Stack in the second phase.	18
4.3	Examples of key insights or notes extracted from the text in the third phase. .	18

LIST OF FIGURES

Bibliography

- [BMS21] Trishala Bhasin, Adam Murray, and Margaret-Anne Storey. “Student experiences with github and stack overflow: An exploratory study”. In: *2021 IEEE/ACM 13th International Workshop on Cooperative and Human Aspects of Software Engineering (CHASE)*. IEEE. 2021, pp. 81–90 (cit. on pp. 4, 8, 62).
- [Bub+23] Sébastien Bubeck, Varun Chadrsekaran, Ronen Eldan, Johannes Gehrke, Eric Horvitz, Ece Kamar, Peter Lee, Yin Tat Lee, Yuanzhi Li, Scott Lundberg, et al. *Sparks of artificial general intelligence: Early experiments with gpt-4*. 2023 (cit. on p. 3).
- [CA24] Bruno Pereira Cipriano and Pedro Alves. ““ ChatGPT Is Here to Help, Not to Replace Anybody” –An Evaluation of Students’ Opinions On Integrating ChatGPT In CS Courses”. In: *arXiv preprint arXiv:2404.17443* (2024) (cit. on pp. 7, 62).
- [CKP20] Preetha Chatterjee, Minji Kong, and Lori Pollock. “Finding help with programming errors: An exploratory study of novice software engineers’ focus in stack overflow posts”. In: *Journal of Systems and Software* 159 (2020), p. 110454 (cit. on p. 4).
- [Fan+23] Angela Fan, Beliz Gokkaya, Mark Harman, Mitya Lyubarskiy, Shubho Sengupta, Shin Yoo, and Jie M Zhang. “Large language models for software engineering: Survey and open problems”. In: *2023 IEEE/ACM International Conference on Software Engineering: Future of Software Engineering (ICSE-FoSE)*. IEEE. 2023, pp. 31–53 (cit. on pp. 2, 3).
- [Gar+23] Manuel B Garcia, Teodoro F Revano, Renato R Maaliw, Pitz Gerald G Lagrazon, Arlene Mae C Valderama, Ari Happonen, Basit Qureshi, and Ramazan Yilmaz. “Exploring Student preference between aI-powered chatGPT and Human-curated stack overflow in resolving programming problems and queries”. In: *2023 IEEE 15th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM)*. IEEE. 2023, pp. 1–6 (cit. on pp. 4, 5, 62).
- [Gee] Geeks for Geeks. NLP. URL: <https://www.geeksforgeeks.org/natural-language-processing-overview/> (cit. on p. 1).

BIBLIOGRAPHY

- [ibma] ibm. *Artificial Intelligence*. URL: <https://www.ibm.com/think/topics/artificial-intelligence> (cit. on p. 1).
- [ibmb] ibm. *Natural Language Processing*. URL: <https://www.ibm.com/think/topics/natural-language-processing> (cit. on p. 1).
- [Kab+24] Samia Kabir, David N Udo-Imeh, Bonan Kou, and Tianyi Zhang. “Is stack overflow obsolete? an empirical study of the characteristics of chatgpt answers to stack overflow questions”. In: *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems*. 2024, pp. 1–17 (cit. on pp. 4, 7, 62).
- [Li+22] Yujia Li, David Choi, Junyoung Chung, Nate Kushman, Julian Schrittwieser, Rémi Leblond, Tom Eccles, James Keeling, Felix Gimeno, Agustin Dal Lago, et al. “Competition-level code generation with alphacode”. In: *Science* 378.6624 (2022), pp. 1092–1097 (cit. on p. 3).
- [Liu+23] Jinrun Liu, Xinyu Tang, Linlin Li, Panpan Chen, and Yepang Liu. “Which is a better programming assistant? A comparative study between chatgpt and stack overflow”. In: *arXiv preprint arXiv:2308.13851* (2023) (cit. on pp. 6, 62).
- [Men23] Pratibha Menon. “Exploring GitHub Copilot assistance for working with classes in a programming course.” In: *Issues in Information Systems* 24.4 (2023) (cit. on pp. 9, 63).
- [PK24] Alan Peslak and Lisa Kovalchick. “AI for coders: An analysis of the usage of ChatGPT and GitHub CoPilot”. In: *Issues in Information Systems* 25.4 (2024), pp. 252–260 (cit. on pp. 10, 63).
- [Quo] Quora. *ChatGPT SO*. URL: <https://www.quora.com/Will-ChatGPT-replace-Stack-Overflow> (cit. on p. 4).
- [Roz+23] Baptiste Roziere, Jonas Gehring, Fabian Gloeckle, Sten Sootla, Itai Gat, Xiaoqing Ellen Tan, Yossi Adi, Jingyu Liu, Romain Sauvestre, Tal Remez, et al. “Code llama: Open foundation models for code”. In: *arXiv preprint arXiv:2308.12950* (2023) (cit. on p. 3).
- [Run+12] Per Runeson, Martin Host, Austen Rainer, and Bjorn Regnell. *Case study research in software engineering: Guidelines and examples*. John Wiley & Sons, 2012 (cit. on p. 17).
- [TIH20] Mohammadreza Tavakoli, Maliheh Izadi, and Abbas Heydarnoori. “Improving quality of a post’s set of answers in stack overflow”. In: *2020 46th Euromicro Conference on Software Engineering and Advanced Applications (SEAA)*. IEEE. 2020, pp. 504–512 (cit. on p. 4).
- [Tur] TurboScribe. *AI tool*. URL: <https://turboscribe.ai/> (cit. on p. 17).
- [x] x. *ChatGPT SO*. URL: https://x.com/castillo_io/status/1599255771736604673?s=20 (cit. on p. 4).

BIBLIOGRAPHY

- [YY23] Ramazan Yilmaz and Fatma Gizem Karaoglan Yilmaz. “Augmented intelligence in programming learning: Examining student views on the use of ChatGPT for programming learning”. In: *Computers in Human Behavior: Artificial Humans 1.2* (2023), p. 100005 (cit. on p. 4).
- [Zim16] Thomas Zimmermann. “Card-sorting: From text to themes”. In: *Perspectives on data science for software engineering*. Elsevier, 2016, pp. 137–141 (cit. on p. 17).

Declaration of Authorship

I hereby declare that the thesis submitted is my unaided work. All direct and indirect sources from published or unpublished third-party contributions are acknowledged as references. This thesis was not previously presented to another examination neither in this nor in a similar form.

Rostock, March 20, 2025

Muhammad Shoaib Hussain

Shoaib Hussain