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# Exploring Students Solutions to Concurrent and Parallel Programming Exercises – Impact of Generative AI

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## ABSTRACT

**Background.** Concurrent and parallel programming is difficult to teach and learn as the understanding of complex and abstract concepts such as nondeterminism, semaphore, and rare conditions, among others, is required [1, 2, 9], having as core issue the synchronisation of processes to achieve a common goal [4]. It is well-acknowledged that concurrent and parallel programming skills are fundamental as nowadays computing is increasingly handled in a parallel manner [7].

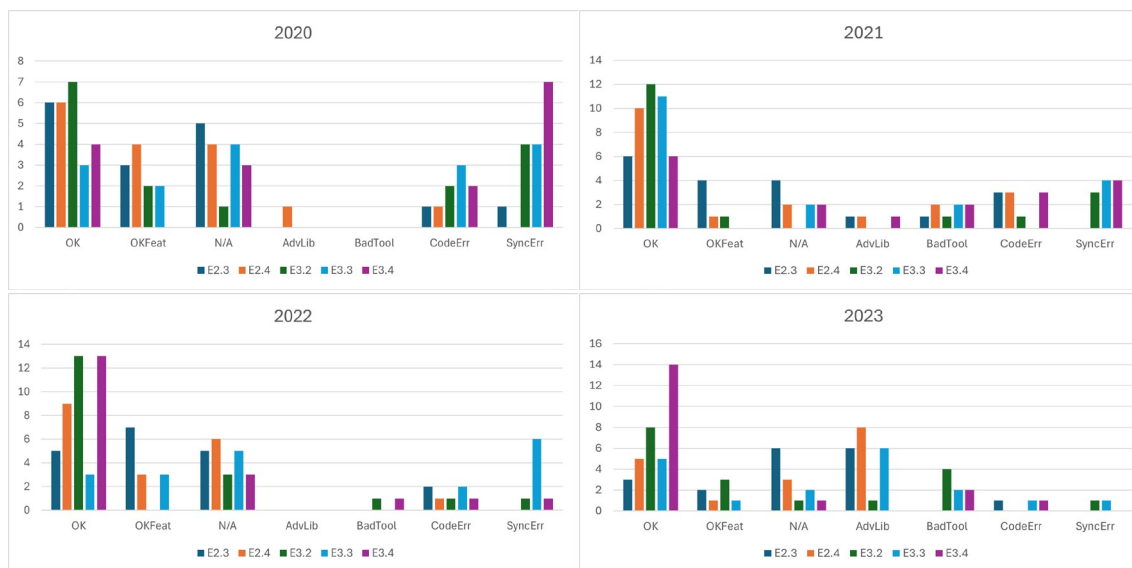
**Problem and Motivation.** Therefore, identifying the pitfalls and successes of students when solving practical concurrent and parallel programming exercises could shed light on best approaches and strategies that they use [3]. In addition, the advent of large language models, and generative AI applications such as ChatGPT, has prompted intensive research on their use in several areas including programming teaching and learning [8]. Yet, the studies in the literature have focused on issues related to learning to program by novice students in introductory courses (e.g., CS1, CS2) [6]. Less work, however, has been presented on the impact of generative AI tools in advanced programming practices such as concurrent and parallel programming.

**Methodology.** To investigate whether generative AI has had an impact on the submitted solutions to concurrent and parallel programming exercises at a university in Japan, we performed a comparison analysis of the students' submissions over 2020–2023. The analysis included five different exercises covering the basis of concurrency through various tasks and scenarios where the implementation of parallel processes is needed as solution. For instance, exercises 2.3 and 2.4 required to create parallel processes and perform independent computations; exercises 3.2 and 3.3, required synchronisation of the parallel processes; and in exercise 3.5 a code template was given for modification. We analysed the submissions of 72 undergraduate 3<sup>rd</sup> year students (avg. 18 students/year) and labelled the solutions using the following nomenclature: OK, indicating a good solution; OKFeat, a good solution but with unusual features; AdvLib, use of unnecessary advanced library or functionality; BadTool, use of an inappropriate tool when the task definition explicitly required a different tool; CodeErr, general coding error; SyncErr, concurrency programming specific error; N/A, solution not submitted or incomplete.

**Results and Analysis.** Results show a substantial increase in the incidence of use of advance libraries (AdvLib) and the wrong tools (BadTool) among students in 2023 for three out of the five analysed exercises. At the same time the concurrency programming-specific errors (SyncErr) also see a reduction in all the exercises. (Figure 1). This

coincides with the availability of generative AI tools such as ChatGPT [5], which warrants further investigations to understand how students, teachers and instructors could harness the affordances of large language models in their concurrent programming learning, teaching, and practice.

**Contribution and Impact.** This paper presents an initial step towards investigating the impact of generative AI on advanced programming topics. This research will continue to uncover strategies for the lecturers and instructors to identify the affordances and use of generative AI and to design exercises that harness these affordances to support students learning of difficult programming concepts.



**Figure 1: Four-year comparison of concurrent and parallel programming exercises solutions**

**CCS CONCEPTS** • Computing methodologies ~ Parallel computing methodologies • Computing methodologies ~ Concurrent computing methodologies ~ Concurrent algorithms

**Additional Keywords and Phrases:** Large language models in advanced programming, Evaluation of students' exercises.

**ACM Reference Format:**

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