Codespec: A Computer Programming Practice Environment

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Figure 1: Codespec logo.

CCS CONCEPTS

- **Applied computing** → **Interactive learning environments**;
- **Human-centered computing** → **Usability testing**.

KEYWORDS

Computer Programming Practice, Adaptive Learning Systems, Scaffolding

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1 ABSTRACT

Computing education researchers (CERs) theorize that learning how to program requires the development of at least four skills: code reading and tracing, code writing, pattern comprehension, and pattern application [see 30]. Developing these skills requires deliberate practice which involves engaging in tasks specifically designed to improve ones' skills in a particular domain [11]. Web-based interactive programming practice environments such as CloudCoder [23], CodeChef [7], CodeLab [1], CodeWars [8], CodingBat[25], Edabit [19], and LeetCode [17] can be considered informal and/or open-ended learning environments (OELEs) that support deliberate practice—the learner decides what to learn and when [3, 12, 24]. OELEs support self-directed learning [14, 16, 18] of computing topics by inspiring programmers to complete projects that are meaningful to them [21], by helping programmers build self-confidence, and by increasing programmers' sense of control over their learning process [5]. But the absence of a predefined curriculum and/or scaffolding, which are tenets of OELEs [12, 16, 18], has led to such environments being criticized for failing to help learners grasp basic computer programming concepts [4, 20]. Learners may form inadequate mental models of basic programming concepts [15], struggle to find good resources, and struggle to get help from real experts when learning in these environments [5]. Hence, Begel and Ko [3], in their chapter on informal learning, call for researchers to investigate whether learning technologies should "structure learning for learners" or whether learners should "be taught how to structure their own independent learning" *outside* of the classroom [p. 763].

We are designing a self-directed learning environment for computer programming practice called Codespec. Its problem space area offers learners the option to switch between solving a problem as either a pseudocode problem (also described as subgoals and programming plans) [6, 22], a Parsons problem [9, 26], a Faded Parsons problem [28], a fix code problem [10], or a write-code problem. Runestone [13] is the only environment that plans to offer programmers the option to solve the same problem as a Parsons problem or write-code problem, and Crescendo aims to support scaffolding for independent learning [27].

Our prototype features a "Help" menu with the options to combine blocks, predict code, reveal distractors, show pseudocode, suggest changes, and provide indentation. Evidence shows programming plans (pseudocode) and purpose-first scaffolds can motivate novice programmers to learn programming [see 6]. We will explore how to incorporate pseudocode across each problem type. And while it is more efficient to solve Parsons problems than fixing and writing code [10], including the latter two types of problems can increase our potential to support a broad range of learners' abilities [29].

Our preliminary research questions are based on prior research on scaffolding self-directed learning with personalized learning and learner modeling in computer science education research (CSEd) [see 2, 18]. They are (1) how do we develop models for personalized learning across the different problem types for an introduction to programming? And (2) what is the effect of personalized scaffolding on self-directed learning in Codespec's adaptive learning environment? To evaluate our prototype and develop a model for personalized learning, we plan to interview stakeholders in computing education and conduct an experiment similar to [18].

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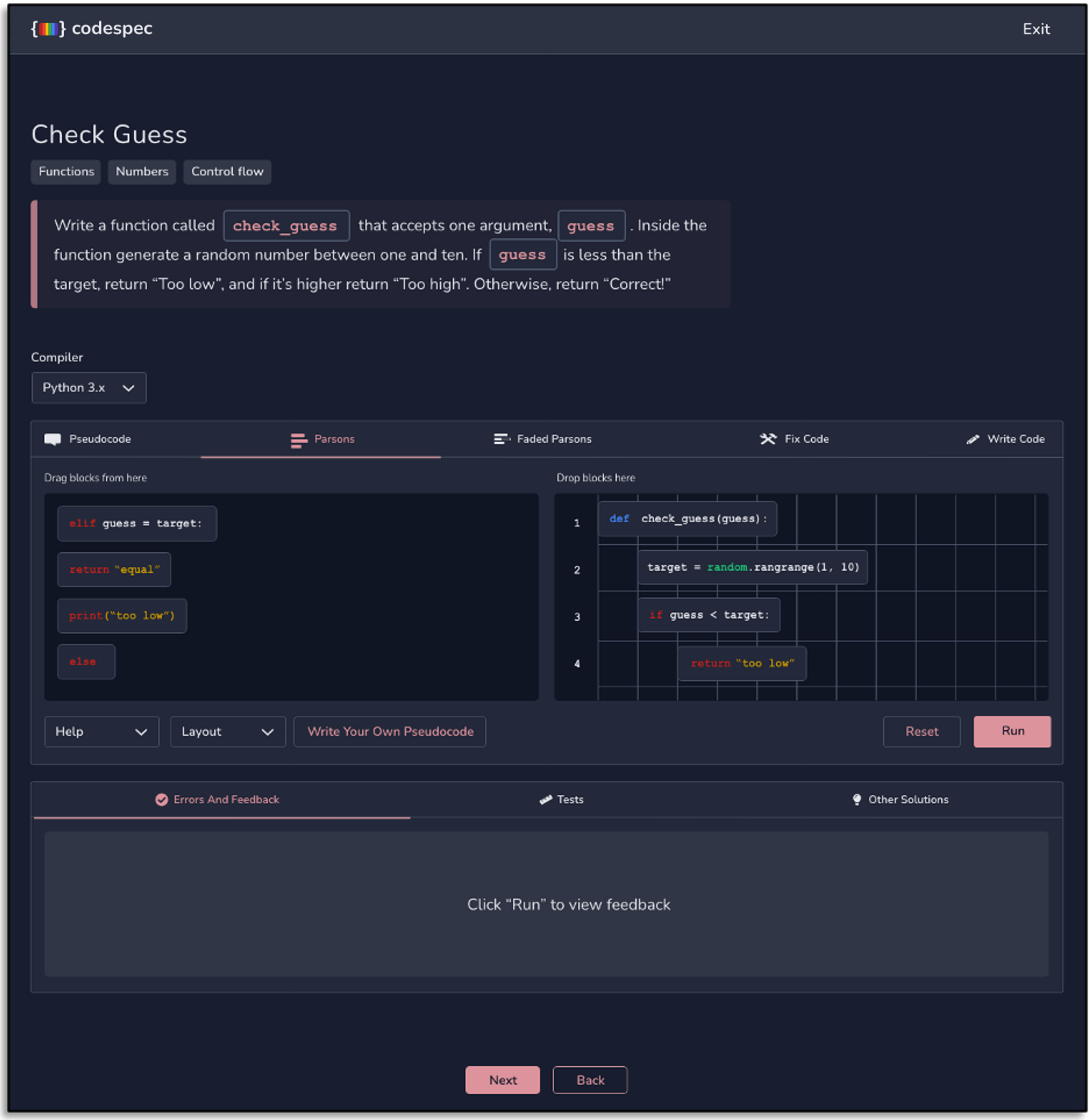

Check Guess

Write a function called check_guess that accepts one argument, guess. Inside the function generate a random number between one and ten. If guess is less than the target, return "Too low", and if it's higher return "Too high". Otherwise, return "Correct!"

Drag blocks from here

```
elif guess = target:
return "equal"
print("too low")
else
```

Drop blocks here

```
def check_guess(guess):
    target = random.rangrange(1, 10)
    if guess < target:
        return "too low"
```

Click "Run" to view feedback

Figure 2: Codespec's practice area on the Parsons problem tab.

The goal is to design a system with diverse stakeholders that will 1) benefit programmers, instructors, and researchers, and 2) cultivate inclusion, diversity, equity, accessibility, and sexual orientation and gender identity awareness (IDEAS).

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