

# On the Cognitive Development of the Novice Programme

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In this presentation, I will review the research that led to my three stage neo-Piagetian theory of how novices understand code. Code tracing is the key. In the first stage, the novice cannot trace code, often due to misconceptions of how programs work. In the second stage, the novice has mastered tracing but, crucially, that is the only skill they have mastered. Maslow's hammer is the cognitive bias that comes from over-use of a mastered tool. As Maslow said (1966), "I suppose it is tempting, if the only tool you have is a hammer, to treat everything as if it were a nail." Novices wielding their tracing hammer will, for example, identify a bug in their code from tracing with specific values, then patch the code to fix the code for those specific values. It is only when novices reach the third stage that they begin to reason about code in a more general, abstract way. The principle failure of traditional approaches to teaching programming has been the assumption that the novices begin at this third stage. Teachers and textbooks typically describe code in terms that are only understood by novices at the third stage. For novices at the earlier two stages, the teacher may as well be speaking a foreign language, and in a sense that is exactly what the teacher is doing. If the widely believed bimodal distribution of programming skill exists, perhaps it separates those students who understand the teacher's language from those who do not. In this presentation, I will review some of the teaching techniques that are appropriate for the students in the first two stages. I will conclude by describing some open questions in this area of research, suggest research approaches to find the answers, and speculate on what those answers may be.