

# Teaching Programming and Design-by-Contract

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**Abstract.** This paper summarizes the experience of teaching an introductory course to programming by using a correctness by construction approach at Innopolis University, Russian Federation. In this paper we claim that division in beginner and advanced groups improves the learning outcomes, present the discussion and the data that support the claim.

## 1 Introduction

Formal methods are still struggling to get a broad acceptance in industry worldwide, and Russia is not an exception. Innopolis is a new IT city [7], incorporating a technopark and a university, aiming at prioritizing the development of IT and software engineering in Tatarstan and in the Russian Federation. Innopolis University (IU) is pioneering several research and pedagogical projects and experiments with innovative teaching methods and curricula. One of the numerous peculiarities of this innovation has been the decision to teach formal methods and correctness by construction together with programming since the first year of the bachelor program. In particular the Eiffel programming language [9] is used as a programming instrument and Design by Contract as a methodological and conceptual tool [8].

This paper summarizes the experience accumulated by following this pedagogical approach. It also reports on the course structure and answers questions related to setup, programming language and chosen paradigm. The work is structured as following: Section 2 motivates the choice of adopting Eiffel as first programming language to be studied. Section 3 describes the structure of the course and the Design by Contract approach adopted. Section 4 reports empirical results on our teaching effort: a poll was presented to students and some data collected. Finally, the numerical data presented is then analyzed and commented in Section 5.

## 2 Eiffel as first language

The choice of Eiffel and Design by Contract as programming and methodological tools for first year bachelors has been long discussed inside the university. After

# Class Interface Design And Programming By Contract

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## **Class Interface Design And Programming By Contract:**

WOON, *White Object-oriented Nights*, 1997      *Computing the Sentence* Anat Ninio, 2025-12-18 Developmental research is abandoning formal syntax probably because Chomskyan generative syntax lacks psychological reality Some studies opt for pure statistics based definitions of syntactic knowledge as if humans were similar to Large Language Models of AI and had no structurally meaningful concepts of syntactic relations Others tend to Constructivist syntax where patterns of elements are said to possess associated semantic meaning The problem is that the core syntactic relations that young children acquire such as verb object and verb subject combinations do not possess particular associated semantics meaning that the Constructivist approach is not a helpful vehicle for understanding syntactic acquisition In this book Anat Ninio approaches syntactic development from a novel point of view within the framework of Relevance Theory a theory of pragmatics with a strong commitment to a cognitive conceptualization of linguistic competence This theory's architecture of linguistic information acknowledges the existence of procedural instructions as part of the content of words covering various processing acts including syntactic combination Methodologically the study employs computer programming algorithms as heuristic models for the cognitive combinatory processes of syntax computer programs being a close analogue to mental plans for solving computational problems The unusual framework and methodology adopted in the book represent a break with current approaches in developmental psycholinguistics and perhaps even with the teachings of mainstream linguistics The first part of the book proposes a procedural syntax of the central patterns of English covering argument structure constructions phrasal and clausal combinations of function words and content words wh questions relative clauses and coordination and gapping This modelling resolves significant issues that have been eluding linguistic theory for decades The second part of the book describes the development of certain syntactic procedures in English speaking children employing a microgenetic analysis to demonstrate that syntactic learning is guesswork by trial and error Despite the apparent chaos the many different attempts that children make to arrive at some syntactic construct belong to a single learning process and gradually converge on the adult algorithm Defining syntax in terms of combinatory procedures provides a novel perspective on our predictive brain on language structure and on cross linguistic variation      Object-oriented Software Construction Bertrand Meyer, 1997 This volume aims to study how practicing software developers in industrial as well as academic environments can use object technology to improve the quality of the software they produce It includes topics on concurrency and Internet programming      **Journal of Object-oriented Programming**, 1996      **Pro Objective-C Design Patterns for iOS** Carlo Chung, 2011-08-28 It's time to capitalize on your mastery of Cocoa with Pro Objective C Design Patterns for iOS You've developed apps that impressed and performed and now you're ready to jump into development practices that will leave you with more effective efficient and professional level apps This book is the element you need to make the jump from journeyman to master All too often developers grind through building good apps on willpower and a

vigorous focus on code development leaving them unaware of and unable to benefit from the underlying structural and functional design patterns Pro Objective C Design Patterns for iOS will teach you those design patterns that have always been present at some level in your code but were never recognized acknowledged or fully utilized Implementation of specific pattern approaches will prove their value to any developer working in the iOS application arena You ll learn to master classic patterns like singleton abstract factory chain of responsibility and observer You ll also discover less well known but useful patterns like memento composite command and mediator

*Formal Methods for Components and Objects* Frank S. de Boer, Marcello M. Bonsangue, Susanne Graf, Willem-Paul de Roever, 2005-09-27 Formal methods have been applied successfully to the verification of medium sized programs in protocol and hardware design However their application to the development of large systems requires more emphasis on specification modelling and validation techniques supporting the concepts of reusability and modifiability and their implementation in new extensions of existing programming languages This book presents revised tutorial lectures given by invited speakers at the Third International Symposium on Formal Methods for Components and Objects FMCO 2004 held in Leiden The Netherlands in November 2004 The 14 revised lectures by leading researchers present a comprehensive account of the potential of formal methods applied to large and complex software systems such as component based systems and object systems The book provides an unique combination of ideas on software engineering and formal methods that reflect the expanding body of knowledge on modern software systems

Design by Contract, by Example Richard Mitchell, Jim McKim, 2002 Design by Contract is a general approach to software design that dramatically improves the quality of the resulting products This book provides an example based approach to learning the powerful concept of Design by Contract

**A Practical Guide to Testing Object-oriented Software** John D. McGregor, David A. Sykes, 2001 David A Sykes is a member of Wofford College s faculty

**Practical Object-Oriented Development in C++ and Java** Cay S. Horstmann, 1997-04-21 Practical OO development tips for the C and Java programmer Practical Object Oriented Development in C and Java offers advice on real world ways to use these powerful programming languages and techniques Using the Unified Modeling Language UML methodology expert Cay S Horstmann gives you clear concise explanations of object oriented design C and Java in a way that makes these potentially daunting operations more accessible than they ve ever been before Horstmann compares and contrasts features of C and Java to give you a deeper understanding of OO design He separates the genuinely useful C Java and UML features from the less effective and potentially harmful ones Horstmann shows you how to determine the best programming practice for whatever application you re in provides the kind of eye opening design tips and style rules that can only come from experience and demystifies advanced topics like frameworks and object persistence Dozens of illuminating programming examples are readily accessible through the accompanying Web site Useful code is available for smart pointers easy output formatting in C and Java a set of classes that makes STL safe to use and a nifty utility that automatically extracts header files This unique

book Offers over 100 practical design hints for good class design Covers the essential OO features of Java 1.1 like serialization and reflection Uses the C Standard Template Library STL throughout Covers CRC cards in addition to UML

**Spring Recipes** Gary Mak, Daniel Rubio, Josh Long, 2010-12-28 The Spring framework is growing It has always been about choice Java EE focused on a few technologies largely to the detriment of alternative better solutions When the Spring framework debuted few would have agreed that Java EE represented the best in breed architectures of the day Spring debuted to great fanfare because it sought to simplify Java EE Each release since marks the introduction of new features designed to both simplify and enable solutions With version 2.0 and later the Spring framework started targeting multiple platforms The framework provided services on top of existing platforms as always but was decoupled from the underlying platform wherever possible Java EE is still a major reference point but it's not the only target OSGi a promising technology for modular architectures has been a big part of the SpringSource strategy here Additionally the Spring framework runs on Google App Engine With the introduction of annotation centric frameworks and XML schemas SpringSource has built frameworks that effectively model the domain of a specific problem in effect creating domain specific languages DSLs Frameworks built on top of the Spring framework have emerged supporting application integration batch processing Flex and Flash integration GWT OSGi and much more

**Professional C++** Marc Gregoire, 2018-03-09 Get up to date quickly on the new changes coming with C++ 17 Professional C++ is the advanced manual for C++ programming Designed to help experienced developers get more out of the latest release this book skims over the basics and dives right in to exploiting the full capabilities of C++ 17 Each feature is explained by example each including actual code snippets that you can plug into your own applications Case studies include extensive working code that has been tested on Windows and Linux and the author's expert tips tricks and workarounds can dramatically enhance your workflow Even many experienced developers have never fully explored the boundaries of the language's capabilities this book reveals the advanced features you never knew about and drills down to show you how to turn these features into real world solutions The C++ 17 release includes changes that impact the way you work with C++ this new fourth edition covers them all including nested namespaces structured bindings string\_view template argument deduction for constructors parallel algorithms generalized sum algorithms Boyer Moore string searching string conversion primitives a filesystem API clamping values optional values the variant type the any type and more Clear explanations and professional level depth make this book an invaluable resource for any professional needing to get up to date quickly Maximize C++ capabilities with effective design solutions Master little known elements and learn what to avoid Adopt new workarounds and testing debugging best practices Utilize real world program segments in your own applications C++ is notoriously complex and whether you use it for gaming or business maximizing its functionality means keeping up to date with the latest changes Whether these changes enhance your work or make it harder depends on how well versed you are in the newest C++ features Professional C++ gets you up to date quickly and provides the answers you need

for everyday solutions      *Readings in Object-Oriented Database Systems* Stanley B. Zdonik, David Maier, 1990 This comprehensive collection is a survey of research in object oriented databases offering a substantive overview of the field section introductions and over 40 research papers presented in their original scope and detail The balanced selection of articles presents a confluence of ideas from both the language and database research communities that have contributed to the object oriented paradigm The editors develop a general definition and model for object oriented databases and relate significant research efforts to this framework Further the collection explores the fundamental notions behind object oriented databases semantic data models implementation of object oriented systems transaction processing interfaces and related approaches Research and theory are balanced by applications to CAD systems programming environments and office information systems      **Technology of Object-oriented Languages and Systems : TOOLS 29** ,1999 The proceedings of the June 1999 conference contains brief outlines of the keynotes tutorials and workshops along with the 35 technical papers presented Numerous papers discuss components frameworks complete architectures and modeling Two key aspects of the Unified Modeling Language receive s      **Designing Software Synthesizer Plug-Ins in C++** Will C. Pirkle, 2014-10-30 Bridging the gap from theory to programming *Designing Software Synthesizer Plug Ins in C For RackAFX VST3 and Audio Units* contains complete code for designing and implementing software synthesizers for both Windows and Mac platforms You will learn synthesizer operation starting with the underlying theory of each synthesizer component and moving on to the theory of how these components combine to form fully working musical instruments that function on a variety of target digital audio workstations DAWs Containing some of the latest advances in theory and algorithm development this book contains information that has never been published in textbook form including several unique algorithms of the author s own design The book is broken into three parts plug in programming theory and design of the central synthesizer components of oscillators envelope generators and filters and the design and implementation of six complete polyphonic software synthesizer musical instruments which can be played in real time The instruments implement advanced concepts including a user programmable modulation matrix The final chapter shows you the theory and code for a suite of delay effects to augment your synthesizers introducing you to audio effect processing The companion website [www.focalpress.com/cw/pirkle](http://www.focalpress.com/cw/pirkle) gives you access to free software to guide you through the application of concepts discussed in the book and code for both Windows and Mac platforms In addition to the software it features bonus projects application notes and video tutorials A reader forum monitored by the author gives you the opportunity for questions and information exchange      [Technology of Object-oriented Languages and Systems : TOOLS 26](#) Raimund K. Ege, Madhu Singh, Bertrand Meyer, 1998 This collection of papers examines the field of database and information systems It includes topics such as distribution and concurrency application design patterns and frameworks Java formal aspects of OO modelling languages and measurement database      **MSDN Magazine** ,2008      **Designing Flexible Object-oriented Systems with UML** Charles Richter, 1999 This is

billed as the only book that puts all the features of the UML notation system into the context of a fully developed example an order processing system Contains the unique insights of an experienced consultant who has coached companies on object oriented design and programming     **Accelerated C# 2005** Trey Nash,2007-02-01 This book provides the fastest path to C mastery for programmers transitioning from another object oriented language Any C programmer at any experience level will find it enlightening It describes how C works in thorough detail discusses the most important issues for expert C coding and demonstrates with short and precise examples how to design and code effective C programs Its succinctness and clarity make it appropriate for anyone familiar with any object oriented language its depth will impress even expert programmers Readers will rapidly become expert in C by learning how to do things the right way right from the start     *Technology of Object-oriented Languages and Systems* Raimund K. Ege,Bertrand Meyer,Madhu Singh,1994 Reflecting the work of many of the leading participants of the TOOLS USA conference held in Santa Barbara in August 1994 this fourteenth TOOLS volume offers a variety of articles of interest to the object oriented community     *Software Factories* Jack Greenfield,Keith Short,2004-09-24 Publisher Description

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