

## CSE341: Programming Languages

### Interlude *Course Motivation*

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### Course Motivation (Did you think I forgot? 😊)

- Why learn the fundamental concepts that appear in all (most?) languages?
- Why use languages quite different from C, C++, Java, Python?
- Why focus on functional programming?
- Why use ML, Racket, and Ruby in particular?
- Not: Language X is better than Language Y

[You won't be tested on this stuff]

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### *Summary*

- No such thing as a "best" PL
- Fundamental concepts easier to teach in some (multiple) PLs
- A good PL is a relevant, elegant interface for writing software
  - There is no substitute for precise understanding of PL semantics
- Functional languages have been on the leading edge for decades
  - Ideas have been absorbed by the mainstream, but very slowly
  - First-class functions and avoiding mutation increasingly essential
  - Meanwhile, use the ideas to be a better C/Java/PHP hacker
- Many great alternatives to ML, Racket, and Ruby, but each was chosen for a reason and for how they complement each other

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What is the best programming language?

What is the best kind of car?

What is the best kind of shoes?

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### *Cars / Shoes*

Different cars are good at rather different things:

- Winning a Formula 1 race
- Taking kids to soccer practice
- Off-roading
- Hauling a mattress

Same with shoes:

- Playing basketball
- Going to a formal
- Going to the beach

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### *More on cars*

- A good mechanic might have a specialty, but also understands how all cars (not a particular make/model) work
  - Would generally not refuse to work on a model they don't personally like
  - Would *definitely* not refuse to work on a car based on the color
- A good mechanical engineer really knows how cars work, how to get the most out of them, and how to design better ones
  - Though probably works on one particular car at any given time
- When first learning to fix (or build) a car, probably shouldn't start with a modern, fancy, high-tech model
  - Why get bogged down in specialized features?

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## Why semantics and idioms

This course focuses as much as it can on semantics and idioms

- Correct reasoning about programs, interfaces, and compilers *requires* a precise knowledge of semantics
  - Not “I feel that conditional expressions might work like this”
  - Not “I like curly braces more than parentheses”
  - Much of software development is designing precise interfaces; what a PL means is a *really* good example
- Idioms make you a better programmer
  - Best to see in multiple settings, including where they shine
  - See Java in a clearer light even if I never show you Java

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## Consider Hamlet...

The play *Hamlet*:

- Is a beautiful work of art
- Teaches deep, eternal truths
- Is the source of some well-known sayings
- Makes you a better person

Continues to be studied centuries later even though:

- The syntax is really annoying to many
- There are more popular movies with some of the same lessons
- Reading Hamlet will not get you a summer internship

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## Are all cars the same?

- Yes:
  - Any car can get you from home to school (once you know how to operate it)
  - All built from the same basic components
    - Engine, transmission, wheels/axles, etc.
  - All have similar interface
    - Steering wheels, gas/brake pedals, headlights, etc.
- No:
  - Details vary
    - E.g. manual v. automatic transmission
  - Buttons/knobs/levers in different places
  - Some go really fast, some have lots of space, some are very comfortable, ...

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## Are all programming languages the same?

Yes:

- Any input-output behavior implementable in language X is implementable in language Y [Church-Turing thesis]
- Java, ML, and a language with one loop and three infinitely-large integers are “the same”

Yes:

- Same fundamentals reappear: variables, abstraction, one-of types, recursive definitions, ...

No:

- The primitive/default/convention in one language is awkward in another
- Personal preferences in syntax, common idioms, etc.
- Beware “the Turing tarpit”

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## Functional Programming

Why spend 60-80% of course using *functional languages*:

- Mutation is discouraged
- Higher-order functions are very convenient
- One-of types via constructs like datatypes

Because:

1. These features are invaluable for correct, elegant, efficient software (great way to think about computation)
2. Functional languages have always been ahead of their time
3. Functional languages well-suited to where computing is going

Most of course is on (1), so a few minutes on (2) and (3) ...

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## Ahead of their time

All these were dismissed as “beautiful, worthless, slow things PL professors make you learn”

- Garbage collection (Java didn't exist in 1995, PL courses did)
- Generics (`List<T>` in Java, C#), much more like SML than C++
- XML for universal data representation (like Racket/Scheme/LISP/...)
- Higher-order functions (Ruby, Javascript, C#, now Java, ...)
- Type inference (C#, Scala, ...)
- Recursion (a big fight in 1960 about this – I'm told ☺)
- ...

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## The future may resemble the past

Somehow nobody notices we are right... 20 years later

- “To conquer” versus “to assimilate”
- Societal progress takes time and muddles “taking credit”
- Maybe pattern-matching, currying, hygienic macros, etc. will be next

## Recent-ish Surge, Part 1

Other popular functional PLs (alphabetized, pardon omissions)

- Clojure <http://clojure.org>
- Erlang <http://www.erlang.org>
- F# <http://tryfsharp.org>
- Haskell <http://www.haskell.org>
- OCaml <http://ocaml.org>
- Scala <http://www.scala-lang.org>

Some “industry users” lists (surely more exist):

- [http://www.haskell.org/haskellwiki/Haskell\\_in\\_industry](http://www.haskell.org/haskellwiki/Haskell_in_industry)
- <http://ocaml.org/companies.html>
- In general, see <http://cufp.org>

## Recent-ish Surge, Part 2

Popular adoption of concepts:

- C#, LINQ (closures, type inference, ...)
- Java 8 (closures)
- MapReduce / Hadoop
  - Avoiding side-effects essential for fault-tolerance here
- Scala libraries (e.g., Akka, ...)
- ...

## Why a surge?

Some *guesses*:

- Concise, elegant, productive programming
- JavaScript, Python, Ruby helped break the Java/C/C++ hegemony
- Avoiding mutation is *the* easiest way to make concurrent and parallel programming easier
  - In general, to handle sharing in complex systems
- Sure, functional programming is still a small niche, but there is so much software in the world today even niches have room

## The languages together

SML, Racket, and Ruby are a useful *combination* for us

	dynamically typed	statically typed
functional	Racket	SML
object-oriented	Ruby	Java

*ML*: polymorphic types, pattern-matching, abstract types & modules

*Racket*: dynamic typing, “good” macros, minimalist syntax, eval

*Ruby*: classes but not types, very OOP, mixins

[and much more]

Really wish we had more time:

*Haskell*: laziness, purity, type classes, monads

*Prolog*: unification and backtracking

[and much more]

## But why not...

Instead of SML, could use similar languages easy to learn after:

- OCaml: yes indeed but would have to port all my materials ☹
  - And a few small things (e.g., second-class constructors)
- F#: yes and very cool, but needs a .Net platform
  - And a few more small things (e.g., second-class constructors, less elegant signature-matching)
- Haskell: more popular, cooler types, but lazy semantics and type classes from day 1

Admittedly, SML and its implementations are showing their age (e.g., `andalso` and less tool support), but it still makes for a fine foundation in statically typed, eager functional programming

### *But why not...*

Instead of Racket, could use similar languages easy to learn after:

- Scheme, Lisp, Clojure, ...

Racket has a combination of:

- A modern feel and active evolution
- "Better" macros, modules, structs, contracts, ...
- A large user base and community (*not* just for education)
- An IDE tailored to education

Could easily define our own language in the Racket system

- Would rather use a good and vetted design

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### *But why not...*

Instead of Ruby, could use another language:

- Python, Perl, JavaScript are also dynamically typed, but are not as "fully" OOP, which is what I want to focus on
  - Python also does not have (full) closures
  - JavaScript also does not have classes but is OOP
- Smalltalk serves my OOP needs
  - But implementations merge language/environment
  - Less modern syntax, user base, etc.

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### *Is this real programming?*

- The way we use ML/Racket/Ruby can make them seem almost "silly" precisely because lecture and homework focus on interesting language constructs
- "Real" programming needs file I/O, string operations, floating-point, graphics, project managers, testing frameworks, threads, build systems, ...
  - Many elegant languages have all that and more
    - Including Racket and Ruby
  - If we used Java the same way, Java would seem "silly" too

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### *A note on reality*

Reasonable questions when deciding to use/learn a language:

- What libraries are available for reuse?
- What tools are available?
- What can get me a job?
- What does my boss tell me to do?
- What is the de facto industry standard?
- What do I already know?

Our course by design does not deal with these questions

- You have the rest of your life for that
- And technology *leaders* affect the answers

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