

# **Engaging, Large-Scale Functional Programming Education in Physical and Virtual Space**

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Kevin Kappelmann, Jonas Rädle, Lukas Stevens

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Technical University of Munich

## Supported by

- Lecturer: Tobias Nipkow
- Manuel Eberl
- 2019: 13 student assistants
- 2020: 22 student assistants

## Challenges

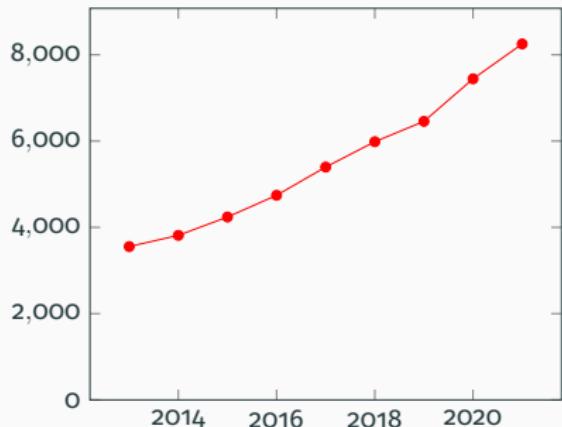
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# Soaring Enrolments

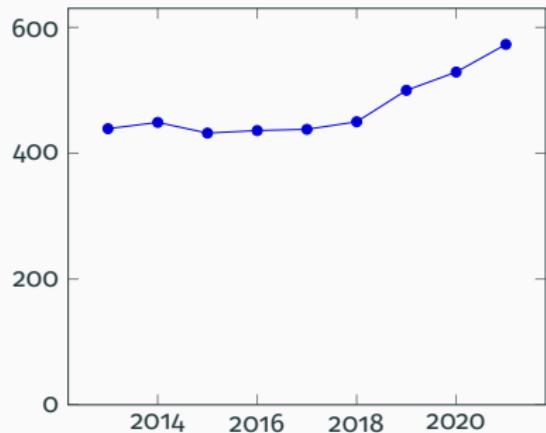
1. Number of Computer Science students exploded

# Soaring Enrolments

Example: Computer Science at TU Munich



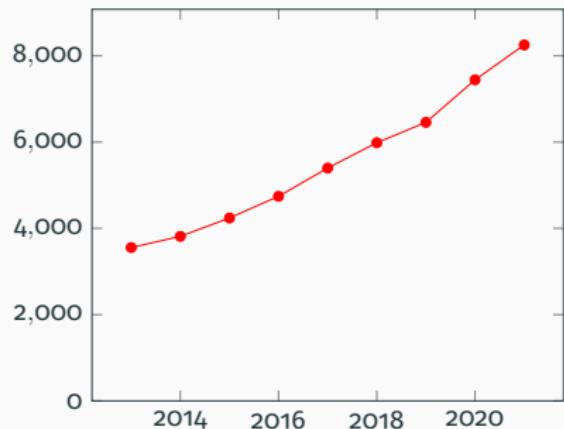
Number of CS students  
(132% increase)



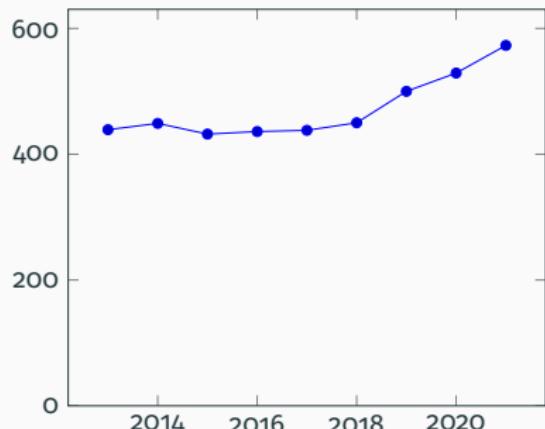
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1000+ students per course are the new normal

# The Pandemic

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2. Radical transition to online classes

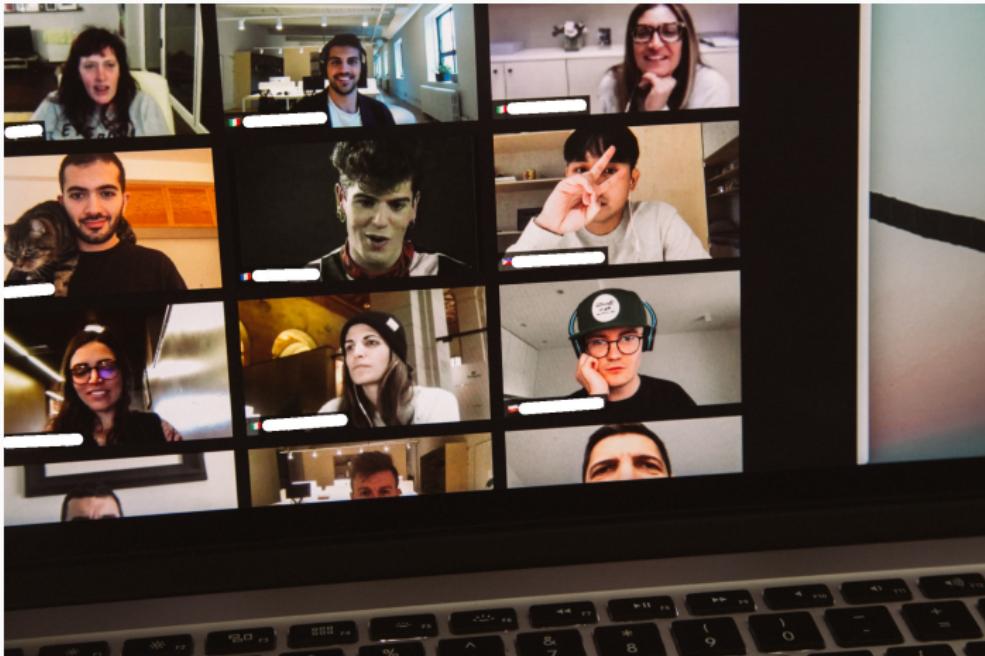
# The Pandemic

How can we go from here...



# The Pandemic

to here...



# The Pandemic

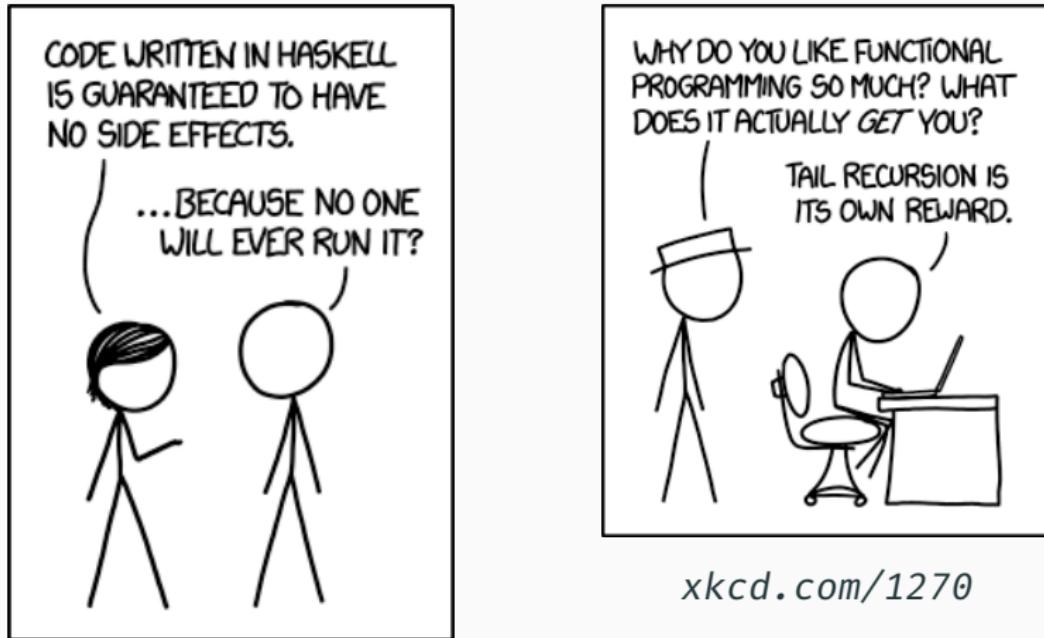
without ending up here?



# Usefulness of Functional Programming

3. Students question the usefulness of functional languages beyond academia

# Usefulness of Functional Programming



[xkcd.com/1312](http://xkcd.com/1312)

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- We share our insights, tools, and exercises for other educators

You can find our resources on:

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Note: We used Haskell, but most ideas apply to any functional programming course

## **Practical Part**

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### **Engagement Mechanisms**

## Grade Bonus

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Result: number of homework submissions severely decreased

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  - Student assistants create engaging exercises instead

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- Little organisational work

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- Online courses are isolating...  
so let us foster social interaction:
  - Pair-programming in tutorials
  - ACM-ICPC-like programming contest
  - Get-together hangout sessions
  - Award ceremonies

# Competitions

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## Code Golf

```
numberToEo = unwords <<< catMaybes <<< reverse <<< flip lookup `zipWith` table <<< chunksOf 3
    <<< pack <<< reverse

topCycle = concatMap snd . ap zip (iterate . fmap nub . concatMap . dominators <*> copeland)

traceFractran rs n = n : fromMaybe [] (traceFractran rs <$> numerator <$>
    (liftM2 eqInteger truncate numerator) `find` map (fromIntegral n *) rs)

bernoulli = genericIndex $ map head $ iterate ((*) `zipWith` enumFrom 1 <<< zipWith subtract
    $ recip `map` enumFrom 1
```

# Competitions

## Optimization

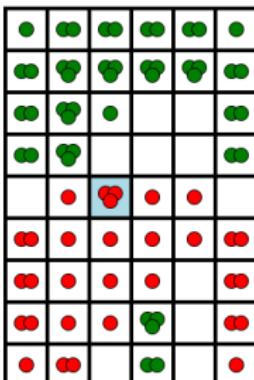
| Rank | Name               | Time [seconds] |
|------|--------------------|----------------|
| 1.   | MC Jr              | 0.02           |
| 2.   | Florian Hübler     | 0.13           |
| 2.   | Luis Bahners       | 0.19           |
| 4.   | Tobias Markus      | 0.35           |
| 4.   | Robert Imschweiler | 0.37           |
| 6.   | Julian Pritzi      | 0.76           |

# Competitions

## Strategy

### 🕹 Tobias Markus vs. Severin Schmidmeier

🏆 Winner: 🟢 Severin Schmidmeier

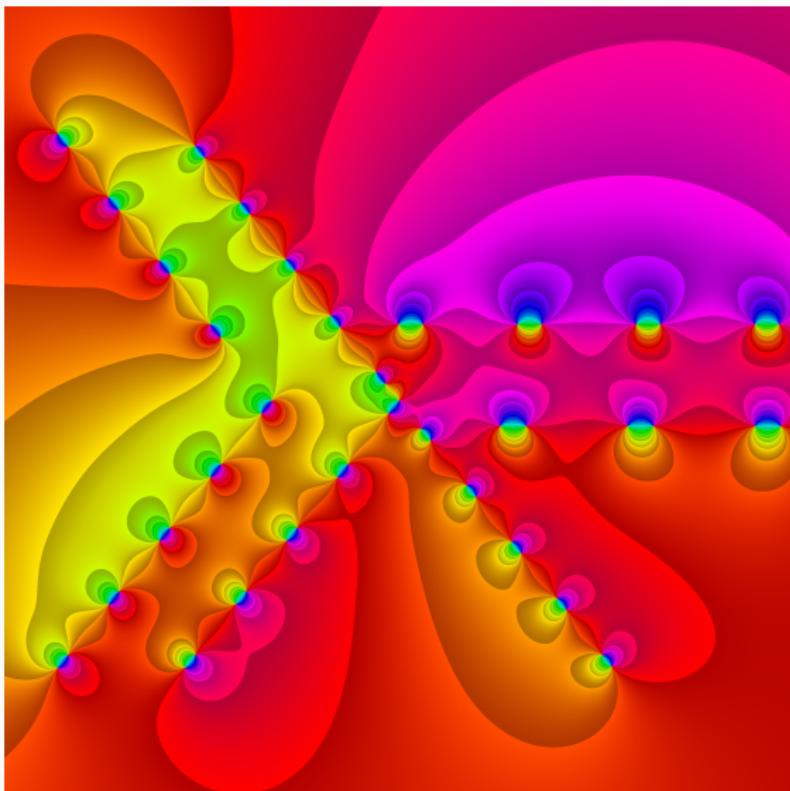


#### 📊 Stats

| 🔴 Statistic        | 🔴 Tobias Markus | 🟢 Severin Schmidmeier |
|--------------------|-----------------|-----------------------|
| Moves made         | 49              | 49                    |
| Orbs captured      | 40              | 89                    |
| Capture/loss ratio | 0.4494          | 2.2250                |

# Competitions

Creativity



# Competitions

## Creativity

```
module Exercise_13 where

import Data.Bool (bool)
import Data.Maybe (fromMaybe)
import Data.List (stripPrefix, isPrefixOf, findIndex, genericIndex)
import Data.Char (ord)
import Data.Word (Word8)
import qualified Data.ByteString as B
import Transform

animate :: [(String, Transform -> Transform)] -> String -> [String]
animate a s = map svg $ scanl (flip applyAnim) (parseInput s) $ map (:) [] a

paint :: String -> String
paint = svg . parseInput
```

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- Works extremely well to motivate talented students...  
*but it is very time-consuming.*

## **Check Your Proof**

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## CYP In A Nutshell

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- Provides instant feedback
- Integrates with Tasty

## Background Theory

```
data List a = [] | a : List a
```

```
[] ++ ys = ys
```

```
(x : xs) ++ ys = x : (xs ++ ys)
```

```
goal xs ++ (ys ++ zs) .=. (xs ++ ys) ++ zs
```

## The [ ] Case

**Lemma:**  $xs \text{ ++ } (ys \text{ ++ } zs) \text{ .=} (xs \text{ ++ } ys) \text{ ++ } zs$

**Proof** by induction on List xs

**Case [ ]**

To show:  $[] \text{ ++ } (ys \text{ ++ } zs) \text{ .=} ([] \text{ ++ } ys) \text{ ++ } zs$

**Proof**

$$[] \text{ ++ } (ys \text{ ++ } zs)$$

(by def  $\text{++}$ )  $\text{.=} ys \text{ ++ } zs$

(by def  $\text{++}$ )  $\text{.=} ([] \text{ ++ } ys) \text{ ++ } zs$

**QED**

# The Cons Case

Case  $x : xs$

To show:  $(x : xs) ++ (ys ++ zs)$

$\therefore=.$   $((x : xs) ++ ys) ++ zs$

IH:  $xs ++ (ys ++ zs) \therefore=.$   $(xs ++ ys) ++ zs$

Proof

$$\begin{array}{ll} & (x : xs) ++ (ys ++ zs) \\ (by \ def \ ++) & \therefore= . x : (xs ++ (ys ++ zs)) \\ (by \ IH) & \therefore= . x : ((xs ++ ys) ++ zs) \end{array}$$

$$\begin{array}{ll} & ((x : xs) ++ ys) ++ zs \\ (by \ def \ ++) & \therefore= . (x : (xs ++ ys)) ++ zs \\ (by \ def \ ++) & \therefore= . x : ((xs ++ ys) ++ zs) \end{array}$$

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## Our Experience With CYP

- Student feedback 18 positive, 3 negative

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- Student feedback 18 positive, 3 negative
- Main criticism: lack of documentation
- Mostly well-structured inductive proofs in the exam

# Find more in our repository!

- IO mocking framework
- ACM-ICPC-like programming contest framework
- A music synthesiser
- More engagement mechanisms and insights, our technical setup,...

*[thub.com/kappelmann/engaging-large-scale-functional-programmi](#)*

## **Future Work**

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# Future Work

Preventing collaboration/cheating



**Any questions?**