RoSE 2022 - SE in RE BS

Should Robotics Engineering Education Include Software Engineering Education?

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Research Questions

For the last 15 years, more and more US schools have been launching Robotics Engineering Bachelor's Degrees

Are there patterns in how these programs choose emphasize software engineering concepts in their courses?

- What concepts do they explicitly emphasize across formal courses?
- What concepts do they cover in capstone projects?

Many Schools are offering these new degrees

Mechatronics and Robotics Engineering - 2

Robotics and Control Engineering - 1

Robotics and Manufacturing Engineering Technology - 1

Robotics and Control Systems Technology - 1

Robotics - 1

Robotics Engineering (Technology) - 11

What are they covering?

Robotics Concepts

Dynamics

Controls

Sensing

…

What are they covering?

García, S., Strüber, D., Brugali, D., Berger, T. and Pelliccione, P., 2020, November. Robotics software engineering: A perspective from the service robotics domain. In *Proceedings of the 28th ACM Joint Meeting on European Software Engineering Conference and Symposium on the Foundations of Software Engineering* (pp. 593-604).

Robotics Concepts

Dynamics

Controls

Sensing

…

Software Engineering Concepts Required for Robotics

Agile Development

Component Based SE

Object Oriented Programming

…

Methodology

Our two authors independently searched descriptions of all major required courses for "mentions" of our concepts (or related concepts)

We tracked which courses these mentions came from in each curriculum.

One program made this easy

CS 3733. SOFTWARE ENGINEERING.

Cat. I

This course introduces the fundamental principles of software engineering. Modern software development techniques and life cycles are emphasized.

Topics include requirements analysis and specification, analysis and design, architecture, implementation, testing and quality, configuration management, and project management.

Students will be expected to complete a project that employs techniques from the topics studied.

This course should be taken before any course requiring a large programming project.

Most programs littered concepts without

CS 114 - Fundamentals of Computing I

4 credit(s)

This is the first course of a two-semester introductory sequence, with laboratory, that covers the fundamentals of algorithmic problem solving. The course emphasizes general programming methodology and concepts common to object-oriented and procedural programming languages: algorithms, top-down structured program design, modularity, efficiency, testing and debugging, and user-friendliness. The object-oriented paradigm is covered, including classes, objects, access control, abstraction, and encapsulation. Other topics include organization and hardware, input and output, subprogram units (methods), fundamental data types, reference types, control structures including conditions and iteration, and arrays.

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Based on the number of mentions in the curriculum we aggregated these mentions into four categories

Animate arrows (3-4) as discussion items
Many SE practices are left unmentioned in robotics BS
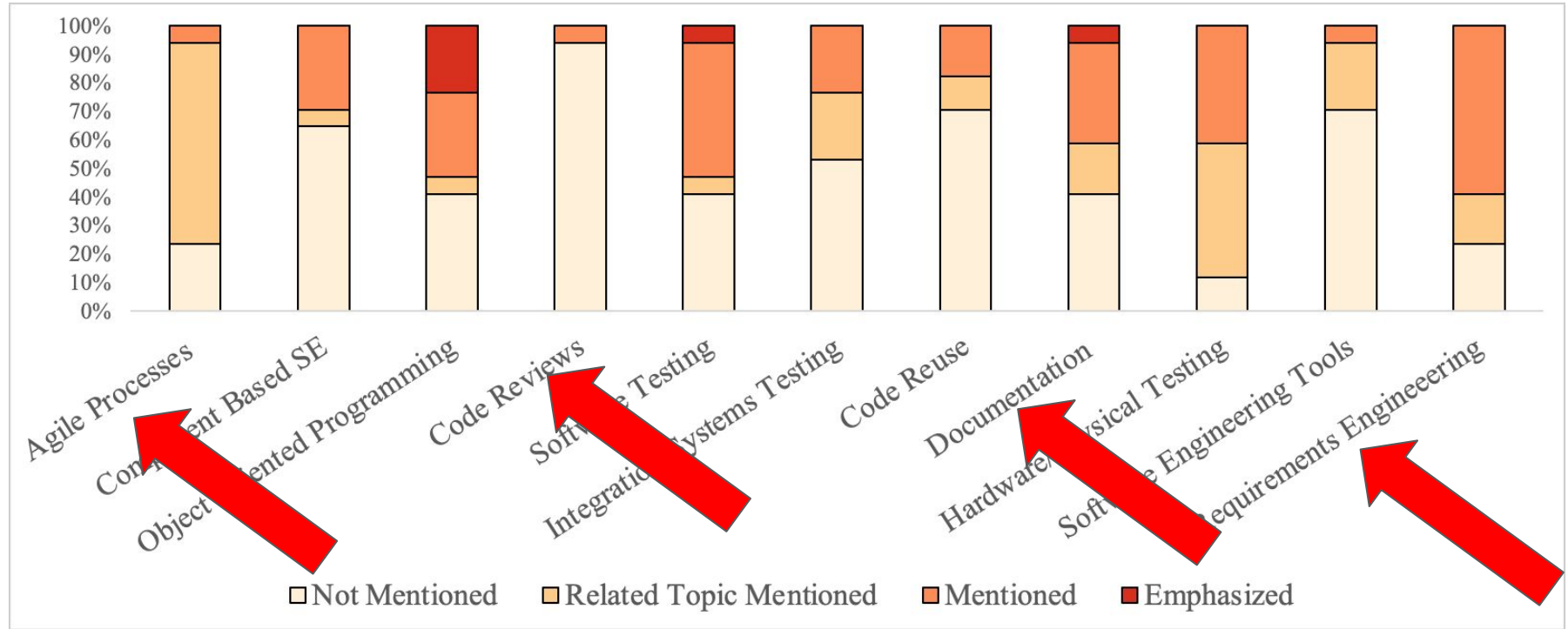
Capstone-style courses

- Capstone-style courses are courses dedicated to semester- or year-long projects done in teams
- All but one program had a capstone-style course requirement
- We collected the descriptions of all of the capstone courses and examined them for common themes

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Capstones as SE practicum

- **Teamwork**
- **Forms of communication**
- **Design**
- **Implementation**
- **Evaluation**
- **Technical Skills**

Future work (for the community!)

Need to engage with Robotics curriculum designers to advocate for additional emphasis on software engineering

Need to cross-train software engineers in robotics concepts in order build teams with comfort in both

Need to further study what concepts are still emphasized in practice, in order to keep teaching up to date

Bonus slide: capstones

- Most capstones were two terms long
  - Some variation in terms of coinciding with other design courses or senior projects or industry co-ops
- All involved presenting the final project in some structured way
  - Sometimes to panels of faculty and/or industry partners
- Prevalence of industry partners for these specific courses indicates that they are a way that schools facilitate an interface between students and industry
  - This is a chance for students to learn SE in an applied manner and for industry partners to show that students are getting a SE education