Qualitative Formative Research
The following slides come from Andrew’s awesome talk in an earlier version of this course (with adaptations by me, so blame me for anything bad about them)!

Practical Prototyping for Programming Tools

Andrew Head, Postdoctoral scholar, UC Berkeley
Objectives

• What prototypes should I make to help me find a good design?
• How should I collect feedback to improve my design?
Who is this guy?
Who is this guy?

Figure 3: Cleaning a notebook with code gathering tools. Over the course of a long analysis, a notebook will become cluttered and inconsistent (1). With code gathering tools, an analyst can select results (e.g., charts, tables, variable definitions, and any other code output) (2) and click “Gather to Notebook” (3) to obtain a minimal, complete, ordered slice that replicates the selected results (4).

Managing Messes in Computational Notebooks, CHI '18
Who is this guy?

Embedded rich text editors for writing prose.

Edits to code automatically propagate across all snippets and the source program.

Outputs update live by assembling the tutorial's snippets in source order and executing them.

Figure 4. Writing tutorials with Torii. Torii helps authors write tutorials by keeping source programs, snippets, and outputs consistent with each other, while still letting authors organize the code in the tutorial flexibly. An edit to code anywhere in the tutorial workspace automatically triggers an update to clones of that code in the source program and snippets, and to all outputs generated from that code.
Who is this guy?

Figure 4. **FixPropagator** interface: The left panel shows all of the incorrect submissions (A). When the teacher selects one, the submission is loaded into the Python code editor in the center of the interface (B). Then the teacher can edit the code, re-run tests, and inspect results. The bottom of the center panel shows the list of tests and console output (C). Once the teacher has fixed the submission, they add some hint that will be shown to current and future students fixed by the same transformation. The bottom of the left panel shows submissions for which the system is suggesting a fix. When the teacher selects a suggested fix, it is shown as a diff in the right panel (D). The teacher can reuse the previously written hint or create a new one (E).
Design methods
Design methods

Design methods for programming tools
THE DESIGN CYCLE

design

prototype

evaluate

design

evaluate

prototype
DESIGN IDEAS DIVERGE AND CONVERGE

# ideas

hundreds!

brainstorming

critique

evaluate

design

prototypes

are used to answer questions about design.

project progress

cycle 1

cycle 2

cycle N...

project done 🎉
Objectives

• What prototypes should I make to help me find a good design?
• How should I collect feedback to improve my design?
Don't look at me!

Discussion time

Think of an idea you had for a programming sometime in the past that you were really excited to work on.

What convincing evidence did you have that it was a good idea?
Brainstorming

1. Defer judgement
2. Encourage wild ideas
3. Build on the ideas of others
4. Stay focused on the topic
5. One conversation at a time
6. Be visual
7. Go for quantity

How do you know these ideas are any good?

From IDEO Design Kit: Brainstorm Rules
FIDELITY

LOW FIDELITY

Many details missing.

HIGH FIDELITY

Looks like final product.
#1 RULE OF PROTOTYPING

Make prototypes with a well-defined purpose and scope. Adjust the fidelity of your prototype to match the purpose and scope.
**SCOPE: WHAT DOES YOUR PROTOTYPE PROTOTYPE?**

- **Role:** function, fit
- **Look and feel:** appearance, sensory experience
- **Implementation:** algorithms, engineering, code

From Houde and Hill – What do Prototypes Prototype?
Role Prototypes
Look-and-Feel Prototypes

Prototypes for the Microsoft mouse
Look-and-Feel Prototypes
Example 3. Implementation prototypes for 3D space-planning application [E3: Chen 1990].
Implementation

Prototypes

```cpp
IntList& IntList::operator=(const IntList& oldList)
{
    register long n = oldList.size;
    if (n != size) setSize(n);
    register int* newPtr = &values[n];
    register int* oldPtr = &oldList.values[n];
    while (n--) **newPtr = **oldPtr;
    return *this;
}
```

Example 12. C++ program sample from a fluid dynamics simulation system [E12: Hill, 1993].
SCOPE: WHAT DOES YOUR PROTOTYPE PROTOTYPE?

Why are the types of prototypes corners of a triangle? What does this mean for scoping your prototypes?

From Houde and Hill – What do Prototypes Prototype?
Why prototype?

- Full implementations take a long amount of time
- At least in research, development teams are only 1 or 2 people
- Solutions need to merge into workspaces that are already complex
After expanding the code some more, it should let me substitute in realistic input values. *These could be captured from the runtime data of my program.* Or maybe they're inferred from typical values an API is called with, mined from open source code online.

Now I've still got some try-catch blocks and if-else statements to remove. When I remove these, I want to make sure the code still runs fine. Others should be able to copy, paste, and run this code, without bugs I've accidentally introduced. So there should be an output pane like this:
Look-and-Feel Prototypes

IDE mockups

You might have found something cool. No one online knows about this pattern. Want to share it? I think it will take about 10 edits.
Assignment 7 - Program Slicing

Submission details: Please submit a .py file. Submit via GradeScope. If you have questions on this process, get in touch via the Slack or via email.
Due: 10/19/20

In class, we worked with a program that generates a control flow graph (CFG) for a limited subset of Python. For this assignment, transform that program into a program slicer.

Required: handle straight-line programs
Strongly encouraged: handle the if then statements we added during class
Extra super awesome: handle loops

Please support this usage:

```
python program_slicing.py filename line_number variable_name
```
FORMATIVE USER RESEARCH
### So many methods!

<table>
<thead>
<tr>
<th>Method</th>
<th>Tool development activities supported</th>
<th>Key benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contextual Inquiry</td>
<td>Requirements and problem analysis</td>
<td>» Experimenter gains insight into day-to-day activities and challenges.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>» Experimenter gains high-quality data on the developer’s intent.</td>
</tr>
<tr>
<td>Exploratory lab studies</td>
<td>Requirements and problem analysis</td>
<td>» Focusing on the activity of interest is easier.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>» Experimenter can compare participants doing the same tasks.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>» Experimenter gains data on the developer’s intent.</td>
</tr>
<tr>
<td>Surveys</td>
<td>» Requirements and problem analysis</td>
<td>» Surveys provide quantitative data.</td>
</tr>
<tr>
<td></td>
<td>» Evaluation and testing</td>
<td>» There are many participants.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>» Surveys are (relatively) fast.</td>
</tr>
<tr>
<td>Data mining</td>
<td>» Requirements and problem analysis</td>
<td>» Data mining provides large quantities of data.</td>
</tr>
<tr>
<td>(including corpus studies</td>
<td>» Evaluation and testing</td>
<td>» Experimenter can see patterns that emerge only with large corpuses.</td>
</tr>
<tr>
<td>and log analysis)</td>
<td></td>
<td></td>
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<td>Natural-</td>
<td>» Requirements and problem analysis</td>
<td>Experimenter gains insight into developer expectations.</td>
</tr>
<tr>
<td>programming</td>
<td>» Design</td>
<td></td>
</tr>
<tr>
<td>elicitation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rapid</td>
<td>Design</td>
<td>Experimenter can gather feedback at low cost before committing to high-cost development.</td>
</tr>
<tr>
<td>prototyping</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heuristic evaluations</td>
<td>» Requirements and problem analysis</td>
<td>» Evaluations are fast.</td>
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<td>» Design</td>
<td>» They do not require participants.</td>
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<td>Cognitive</td>
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<td>» Walkthroughs are fast.</td>
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</tr>
<tr>
<td>Think-aloud</td>
<td>» Requirements and problem analysis</td>
<td>Evaluations reveal usability problems and the developer’s intent.</td>
</tr>
<tr>
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<td>» Design</td>
<td></td>
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<tr>
<td>evaluations</td>
<td>» Evaluation and testing</td>
<td></td>
</tr>
<tr>
<td>A/B testing</td>
<td>Evaluation and testing</td>
<td>» Testing provides direct evidence that a new tool or technique benefits developers.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>» It provides objective numbers.</td>
</tr>
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When to use a design method

I need to understand the problem

I need to evaluate the solution

fast to plan and run

actionable design insight
When to use a design method

I need to understand the problem

I need to evaluate the solution

actionable design insight

content analyses

fast to plan and run

fast to plan and run
When to use a design method

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When to use a design method

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  - interviews
  - surveys
  - content analyses
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I need to evaluate the solution
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When to use a design method
When to use a design method

I need to understand the problem

- actionable design insight
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- interviews
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- observations with existing tools

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- observations with existing tools
- interviews
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- fast to plan and run
- experiments
When to use a design method

I need to understand the problem

- observations with existing tools
- interviews
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fast to plan and run

I need to evaluate the solution

- observations with your tool
- experiments

fast to plan and run

actionable design insight
When to use a design method

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actionable
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When to use a design method
- design critique
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Understanding Problems in a Time Crunch: Observations

Answers the questions,

(1) "Did I pick an **actual** problem?"

(2) "What **issues** can a tool help fix?"
Observations

designed thing

user
Observations

facilitator
user
greets user, gives tutorial, asks and answers questions
Observations

facilitator  user  observer
designed thing

takes focused, complete notes
Highly recommend the expert-apprentice relationship model for contextual inquiry. Don’t typically recommend offering piggyback rides as part of it.
FORMATIVE STUDY
We conducted a formative study to understand the process that programmers follow when creating executable code examples from their own code, and the obstacles they encounter along the way. We observed 12 programmers as they created example code. Participants were recruited from our professional networks, local MeetUps, and computer science researchers from a local university.

This study and a review of literature on code examples led to design recommendations for improving the user experience of extracting code examples from existing code (Figure 2). We refer the reader to Section A1 of the auxiliary material for protocol details and observations from the formative study.

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**Making examples could be time-consuming because...**  
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- Omit code except for explicit code selections and necessary fixes |
Transcription errors

Edit errors

Forgotten code

...and time-consuming removal of dead code
1. Keep It focused

1. Make your research questions before the study. Iterate. Keep the good ones.

2. Help users understand what feedback is actionable to you—and what's not
   a. Set the parameters of the conversation early
   b. Provide on-going guidance
ANDREW'S MAXIMUM-FUN, MINIMUM-REGRET OBSERVATION TIPS

2. Plan your notes for fast analysis

1. Take notes and record the conversation
2. **Structure your notes** document to make analysis easy and fast
3. Start synthesizing right after the study
**When Guide Rails Are Helpful**

**Directing Focus to What Work Still Had to be Done**
- Participants generally reported that it was helpful to get quick feedback on whether their code was working and get suggestions of definitions to include (e.g., `N04`).
- “[the features this participant marked as most important]: ‘it was a lot easier to write code that was correct’ task of making an example that worked rather than working out which variables I needed to declare, etc.’” (N07)

**Making Quick Work of Otherwise Tedious Trial and Error**
- The value of small, automatic fixes
  - “although not necessarily hard to do, [all of the other features] example a lot easier because I just had to look at the relevant file and see if I needed it or not instead of having to manually add them in.” (N04)
  - “It fills in a lot of things that people usually don’t really think about (exceptions, variables/constants) and saves a lot of time spent just searching and copy/pasting.” (N04)
  - “Rockit saved me the trouble of having to go through and find things like undeclared variables, missing import statements, and unchecked exceptions, which prevented my Sierra code from compiling.” (N05)
- Some of the many small fixes CodeScoop made automatically, but that participants had to do manually in the baseline

**TARGETED NOTES**

A section for each research question (make before study)

Interpretation (add in real time)

evidence (quotes, observations, add in real time)

user IDs
ANDREW'S MAXIMUM-FUN, MINIMUM-REGRET OBSERVATION TIPS

3. Develop rapport with users

1. There's always time for a bit of small talk
   a. Make them feel **comfortable**
   b. Make them feel **appreciated** (they're doing you a huge favor!)
   c. Make them **want to help again**
Answers the questions,

(1) "Does this solve the problem?"

(2) "Is this something that users (and my peers) will get excited about?"
Getting Feedback on Programming Tools Before They're Built

- Get feedback from *multiple users*
- Get feedback from *multiple tool builders*
- Present *multiple ideas*, not just one
- Come up with *concrete worked examples*
- Be open to new ideas
1. Get Feedback from Multiple Users

Programmers have diverse work styles and preferences. Here's one way of looking at differences in work styles.

- "Opportunistic programmers are more concerned with productivity than control or understanding."
- "Pragmatic programmers balance productivity with control and understanding."
- "Systematic programmers program defensively and these are the programmers for whom low-level APIs are targeted."

From Clarke, "Measuring API Usability", Dr. Dobb's Elaborated on in Stylos and Clarke, "Usability Implications of Requiring Parameters in Objects' Constructors", ICSE '07
1. Get Feedback from Multiple Users

<table>
<thead>
<tr>
<th>Motivations</th>
<th>People have different motivations for using technology:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• <strong>Abby</strong> uses technology <em>only as needed for his/her task</em>. S/he prefers familiar features to keep focused on the task.</td>
</tr>
<tr>
<td></td>
<td>• <strong>Tim</strong> likes using technology to learn what new features can help him/her accomplish.</td>
</tr>
<tr>
<td></td>
<td>• <strong>Pat</strong> is like Abby in <em>some situations</em> and like Tim in others. Make clear what a new feature does, and why someone would use it, but also keep familiar features available.</td>
</tr>
</tbody>
</table>

Support **ALL TYPES** of users and their Cognitive Styles

GenderMag personas, gendermag.org
2. Get Feedback from Tool Builders

"When artists assessed one another's performances, they were about twice as accurate as managers and test audiences in predicting how often the videos would be shared. Compared to creators, managers and test audiences were 56 percent and 55 percent more prone to major false negatives, undervaluing a strong, novel performance by five ranks or more in the set of ten they viewed."

From Adam Grant, Originals, regarding Justin Berg's publication, "Balancing on the Creative Highwire: Forecasting the Success of Novel Ideas in Organizations"
3. Present Multiple Ideas, Not Just One

- Critics are more willing to give substantive feedback when there are several ideas in play.
- Designs that evolve from parallel prototypes (rather than sequential prototypes).
Getting the Right Design and the Design Right: Testing Many Is Better Than One

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William Buxton  
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University of Toronto  
Toronto, Canada  
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Abigail Sellen  
Microsoft Research  
Cambridge, UK  
asellen@microsoft.com

ABSTRACT
We present a study comparing usability testing of a single interface versus three functionally equivalent but stylistically distinct designs. We found that when presented with a single design, users give significantly higher ratings and were more reluctant to criticize than when presented with the same design in a group of three. Our results imply that by presenting users with alternative design solutions, subjective ratings are less prone to inflation and give rise to more and stronger criticisms when appropriate. Contrary to our expectations, our results also suggest that usability testing by itself, even when multiple designs are presented, is not an effective vehicle for soliciting constructive suggestions about how to improve the design from end users. It is a means to identify problems, not provide solutions.

Figure 1. The “Circular” paper prototype

Figure 2. The “Tabular” paper prototype
Parallel Prototyping Leads to Better Design Results, More Divergence, and Increased Self-Efficacy

STEVEN P. DOW, ALANA GLASSCO, JONATHAN KASS, MELISSA SCHWARZ, DANIEL L. SCHWARTZ, and SCOTT R. KLEMMER
Stanford University

Fig. 1. The experiment manipulates when participants receive feedback during a design process: in serial after each design (top) versus in parallel on three, then two (bottom).

Iteration can help people improve ideas. It can also give rise to fixation, continuously refining one option without considering others. Does creating and receiving feedback on multiple prototypes in parallel, as opposed to serially, affect learning, self-efficacy, and design exploration? An experiment manipulated whether independent novice designers created graphic Web advertisements in parallel or in series. Serial participants received descriptive critique directly after each prototype. Parallel participants created multiple prototypes before receiving feedback. As measured by click-through data and expert ratings, ads created in the Parallel condition significantly outperformed those from the Serial condition. Moreover, independent raters found Parallel prototypes to be more diverse. Parallel participants also reported a larger increase in task-specific self-confidence. This article outlines a theoretical foundation for why parallel prototyping produces better design results and discusses the implications for design education.

Categories and Subject Descriptors: H.1.m. [Information Systems]: Models and Principles
General Terms: Experimentation, Design
4. Come up with concrete worked examples

Worked examples, or scenarios of tool usage showing real programs.

These let you simultaneously to start testing the *functionality* and *fit* of your idea while thinking about *implementation feasibility*.
WIZARD OF OZ STUDY

The computer / "wizard" updates the prototype in response to user actions.

Prototyped thing

Facilitator

User

Observer
Why is it called "Wizard-of-Oz"?

The illusion looks real...
Why is it called "Wizard-of-Oz"?

The illusion looks real...

...but it's just a person controlling it.
A Discount Idea Evaluation Method

• Make a deck of slides
• Create a demo walkthrough of your 3 most exciting tool ideas
  • They show real programs, real text
  • They come with a problem description, solution description, and resolution
• Show this to 3 users, 3 tool builders. Ask questions that help you figure out if they’ve actually understood the tool and what they’d have to do to use it.
public class ControlFlowTest extends LightCodeInsightTestCase {
    private static final String BASE_PATH = "testData/psi/controlFlow";

    private static void doTestFor(final File file) throws Exception {
        String contents = StringUtil.convertLineSeparators(FileUtil.loadFile(file));
        configureFromFileText(file.getName(), contents);
        Pattern pattern = Pattern.compile("^//\s*(.*)", Pattern.DOTALL);
        Matcher matcher = pattern.matcher(contents);
        assertTrue(matcher.matches());
        final String policyClassName = matcher.group(1);
        final ControlFlowPolicy policy;
        if ("LocalsOrMyInstanceFieldsControlFlowPolicy".equals(policyClassName)) {
            policy = LocalsOrMyInstanceFieldsControlFlowPolicy.getInstance();
        } else {
            policy = null;
        }
        final int offset = getEditor().getcaretModel().getOffset();
        PsiElement element = getFile().findElementAt(offset);
        element = PsiTreeUtil.getParentOfType(element, PsiCodeBlock.class, false);
        ControlFlow controlFlow = ControlFlowFactory.getInstance(getProject()).getControlFlow(element, policy);
        String result = controlFlow.toString().trim();
        final String expectedFullPath = StringUtil.trimEnd(file.getPath(), ".java") + ".txt";
        VirtualFile expectedFile = LocalFileSystem.getInstance().findFileByPath(expectedFullPath);
        String expected = LoadTextUtil.loadText(expectedFile).toString().trim();
        expected = expected.replaceAll(\r, "]n", expected, result);
    }

    private static void doAllTests() throws Exception {
        final String testDirPath = BASE_PATH;
        File testDir = new File(testDirPath);
        final File[] files = testDir.listFiles((dir, name) -> name.endsWith(".java"));
        for (int i = 0; i < files.length; i++) {
            File file = files[i];
            doTestFor(file);
            System.out.print((i + 1) + " ");
        }
    }

}
public class ControlFlowTest extends LightCodeInsightTestCase {
{
    @NonNls
    private static final String BASE_PATH = "testData/psi/controlFlow";

    private static void doTestFor(final File file) throws Exception {
        String contents = StringUtil.convertLineSeparators(FileUtil.loadFile(file));
        configureFromFileText(file.getName(), contents);
        // extract factory policy class name
        Pattern pattern = Pattern.compile("^//\S*\")
            Pattern.DOTALL
            Matcher matcher = pattern.matcher(contents);
            assertTrue(matcher.matches());
        final String policyClassName = matcher.group(1);
        final ControlFlowPolicy policy;
        if ("LocalsOrMyInstanceFieldsControlFlowPolicy".equals(policyClassName)) {
            policy = LocalsOrMyInstanceFieldsControlFlowPolicy.getInstance();
        } else {
            policy = null;
        }

        final int offset = getEditor().getCareModel().getOffset();
        PsiElement element = getFile().findElementAt(offset);
        element = PsiTreeUtil.getParentOfType(element, PsiCodeBlock.class, false);
        assertTrue("Selected element: " + element, element instanceof PsiCodeBlock);

        ControlFlow controlFlow = ControlFlowFactory.getInstance(getProject()).getControlFlow(element, policy);
        String result = controlFlow.toString().trim();

        final String expectedFullPath = StringUtil.trimEnd(file.getPath(), "java") + "txt";
        VirtualFile expectedFile = LocalFileSystem.getInstance().findFileByPath(expectedFullPath);
        String expected = LoadTextUtil.loadText(expectedFile).toString().trim();
        expected = expected.replaceAll("\r", "");
        assertEquals("Text mismatch (in file " + expectedFullPath + ":\n", expected, result);
    }

    // Not sure why this is failing on some simple tests (like flow3). It looks like the branching, reading, and
    // writing structure is correctly captured. So maybe we should just update the test output.
    private static void doAllTests() throws Exception {
        final String testDirPath = BASE_PATH;
        File testDir = new File(testDirPath);
        final File[] files = testDir.listFiles((dir, name) -> name.endsWith("java"));
        for (int i = 0; i < files.length; i++) {
            final File file = files[i];
            doTestFor(file);
        }
    }
}
public class ControlFlowTest extends LightCodeInsightTestCase {
    {
        @NonNls
        private static final String BASE_PATH = "testData/psi/controlFlow";

        private static void doTestFor(final File file) throws Exception {
            String contents = StringUtil.convertLineSeparators(FileUtil.loadFile(file));
            configureFromFileText(file.getName(), contents);
// extract factory policy class name
            Pattern pattern = Pattern.compile("^//S*/.*\", Pattern.DOTALL);
            Matcher matcher = pattern.matcher(contents);
            assertTrue(matcher.matches());
            final String policyClassName = matcher.group(1);
            final ControlFlowPolicy policy;
            if ("LocalsOrMyInstanceFieldsControlFlowPolicy".equals(policyClassName)) {
                policy = LocalsOrMyInstanceFieldsControlFlowPolicy.getInstance();
            } else {
                policy = null;
            }

            final int offset = getEditor().getCareModel().getOffset();
            PsiElement element = getEditor().findElementAt(offset);
            element = PsiTreeUtil.getParentOfType(element, PsiCodeBlock.class, false);
            assertTrue("Selected element: "+ element, element instanceof PsiCodeBlock);
            ControlFlow controlFlow = ControlFlowFactory.getInstance(getProject()).getControlFlow(element, policy);

            String result = controlFlow.toString().trim();

            final String expectedFullPath = StringUtil.trimEnd(file.getPath(), ".java") + ".txt";
            VirtualFile expectedFile = LocalFileSystem.getInstance().findFileByPath(expectedFullPath);
            String expected = LoadTextUtil.loadText(expectedFile).toString().trim();
            expected = expected.replaceAll("\r", "");
            assertEquals("Text mismatch (in file " + expectedFullPath + ")\n", expected, result);
        }
    }

    // Not sure why this is failing on some simple tests (like flow3). It looks like the branching, reading, and
    // writing structure is correctly captured. So maybe we should just update the test output.
    private static void doAllTests() throws Exception {
        final String testDirPath = BASE_PATH; File testDir = new File(testDirPath);
        final File[] files = testDir.listFiles((dir, name) -> name.endsWith(".java"));
        for (int i = 0; i < files.length; i++) {
            File file = files[i]; doTestFor(file);
            System.out.print((i + 1) + " ");
        }
    }
}
public class ControlFlowTest extends LightCodeInsightTestCase {
{
    @NonNls
    private static final String BASE_PATH = "testData/psi/controlFlow";

    private static void doTestFor(final File file) throws Exception {
        String contents = StringUtil.convertLineSeparators(FileUtil.loadFile(file));
        configureFromFileText(file.getName(), contents);
        Pattern pattern = Pattern.compile("//(.*$)", Pattern.DOTALL);
        Matcher matcher = pattern.matcher(contents);
        assertTrue(matcher.matches());
        final String policyClassName = matcher.group(1);
        final ControlFlowPolicy policy;
        if ("LocalsOrMyInstanceFieldsControlFlowPolicy".equals(policyClassName)) {
            policy = LocalsOrMyInstanceFieldsControlFlowPolicy.getInstance();
        } else {
            policy = null;
        }

        final int offset = getEditor().getCareModel().getOffset();
        PsiElement element = getFile().findElementAt(offset);
        element = PsiTreeUtil.getParentOfType(element, PsiCodeBlock.class, false);
        assertTrue("Selected element:", element instanceof PsiCodeBlock);
        ControlFlow controlFlow = ControlFlowFactory.getInstance(getProject()).getControlFlow(element, policy);

        final String expectedFullPath = StringUtil.trimEnd(file.getPath(), ".java") + ".txt";
        VirtualFile expectedFile = LocalFileSystem.getInstance().findFileByPath(expectedFullPath);
        String expected = LoadTextUtil.loadText(expectedFile).toString().trim();
        expected = expected.replaceAll("\r", "");
        assertEquals("Text mismatch (in file " + expectedFullPath + "):\n", expected, result);
    }

    // Not sure why this is failing on some simple tests (like flow3). It looks like the branching, reading,
    // and writing structure is correctly captured. So maybe we should just update the test output.
    private static void doAllTests() throws Exception {
        final String testDirPath = BASE_PATH;
        File testDir = new File(testDirPath);
        final File[] files = testDir.listFiles((dir, name) -> name.endsWith(".java"));
        for (int i = 0; i < files.length; i++) {
            final File file = files[i];
            doTestFor(file);

            System.out.print((i + 1) + ";");
        }
    }
}
public class ControlFlowTest extends LightCodeInsightTestCase {

    private static final String BASE_PATH = "testData/psi/controlFlow";

    private static void doTestFor(final File file) throws Exception {
        String contents = StringUtil.convertLineSeparators(FileUtil.loadFile(file));
        configureFromFileText(file.getName(), contents);
        Pattern pattern = Pattern.compile("^//\s*(.*)", Pattern.DOTALL);
        Matcher matcher = pattern.matcher(contents);
        final String policyClassName = matcher.group(1);
        final ControlFlowPolicy policy;
        if ("LocalsOrMyInstanceFieldsControlFlowPolicy".equals(policyClassName)) {
            policy = LocalsOrMyInstanceFieldsControlFlowPolicy.getInstance();
        } else {
            policy = null;
        }
        final int offset = getEditor().getCareModel().getOffset();
        PsiElement element = getFile().findElementAt(offset);
        element = PsiTreeUtil.getParentOfType(element, PsiCodeBlock.class, false);
        assertTrue("Selected element: "+ element, element instanceof PsiCodeBlock);
        ControlFlow controlFlow = ControlFlowFactory.getInstance(getProject()).getControlFlow(element, policy);
        String result = controlFlow.toString().trim();
        final String expectedFullPath = StringUtil.trimEnd(file.getPath(), ".java") + ".txt";
        VirtualFile expectedFile = LocalFileSystem.getInstance().findFileByPath(expectedFullPath);
        String expected = LoadTextUtil.loadText(expectedFile).toString().trim();
        expected = expected.replaceAll("\r", "");
        assertEquals("Text mismatch (in file "+ expectedFullPath + ":\n", expected, result);
    }

    // Not sure why this is failing on some simple tests (like flow3). It looks like the branching, reading, and
    // writing structure is correctly captured. So maybe we should just update the test output.
    private static void doAllTests() throws Exception {
        final String testDirPath = BASE_PATH; File testDir = new File(testDirPath);
        final File[] files = testDir.listFiles((dir, name) -> name.endsWith(".java"));
        for (int i = 0; i < files.length; i++) {
            File file = files[i];
            doTestFor(file);
            System.out.print((i + 1) + " ");
        }
    }
}
public class ControlFlowTest extends LightCodeInsightTestCase {
    {
        @NonNls
        private static final String BASE_PATH = "testData/psi/controlFlow";

        private static void doTestFor(final File file) throws Exception {
            String contents = StringUtil.convertLineSeparators(FileUtil.loadFile(file));
            configureFromFileText(file.getName(), contents);
            // extract factory policy class name
            Pattern pattern = Pattern.compile("^//\S*\.
\S+.*", Pattern.DOTALL);
            Matcher matcher = pattern.matcher(contents);
            assertTrue(matcher.matches());
            final String policyClassName = matcher.group(1);
            final ControlFlowPolicy policy;
            if ("LocalsOrMyInstanceFieldsControlFlowPolicy".equals(policyClassName)) {
                policy = LocalsOrMyInstanceFieldsControlFlowPolicy.getInstance();
            } else {
                policy = null;
            }

            final int offset = getEditor().getCareModel().getOffset();
            PsiElement element = getFile().findElementAt(offset);
            // Selected element: element, element instanceof PsiCodeBlock;

            ControlFlow controlFlow = ControlFlowFactory.getInstance(getProject()).getControlFlow(element, policy);
            String result = controlFlow.toString().trim();

            final String expectedFullPath = StringUtil.trimEnd(file.getPath(), ".java") + ".txt";
            VirtualFile expectedFile = LocalFileSystem.getInstance().findFileByPath(expectedFullPath);
            String expected = LoadTextUtil.loadText(expectedFile).toString().trim();
            expected = expected.replaceAll("\r", "");
            assertEquals("Text mismatch (in file " + expectedFullPath + ")\n", expected, result);

        }

        private static void doAllTests() throws Exception {
            final String testDirPath = BASE_PATH;
            File testDir = new File(testDirPath);
            final File[] files = testDir.listFiles((dir, name) -> name.endsWith(".java"));
            for (int i = 0; i < files.length; i++) {
                File file = files[i];
                doTestFor(file);
            }
            System.out.print((i + 1) + ".");
        }
    }
}
public class ControlFlowTest extends LightCodeInsightTestCase {
    { @NonNls
    private static final String BASE_PATH = "testData/psi/controlFlow";

    private static void doTestFor(final File file) throws Exception {
        String contents = StringUtil.convertLineSeparators(FileUtil.loadFile(file));
        configureFromFileText(file.getName(), contents);
        // extract factory policy class
        Pattern pattern = Pattern.compile("^//(.*)", Pattern.DOTALL);
        Matcher matcher = pattern.matcher(contents);
        assertTrue(matcher.matches());
        final String policyClassName = matcher.group(1);
        final ControlFlowPolicy policy;
        if ("LocalsOrMyInstanceFieldsControlFlowPolicy".equals(policyClassName)) {
            policy = LocalsOrMyInstanceFieldsControlFlowPolicy.getInstance();
        } else {
            policy = null;
        }

        final int offset = getEditor().getCareModel().getOffset();
        PsiElement element = getFile().findElementAt(offset);
        element = PsiTreeUtil.getParentOfType(element, PsiCodeBlock.class, false);
        assertTrue("Selected element: ", element, element instanceof PsiCodeBlock);

        ControlFlow controlFlow = ControlFlowFactory.getInstance(getProject()).getControlFlow(element, policy);
        String result = controlFlow.toString().trim();

        final String expectedFullPath = StringUtil.trimEnd(file.getPath(), ".java") + ".txt";
        VirtualFile expectedFile = LocalFileSystem.getInstance().findFileByPath(expectedFullPath);
        String expected = LoadTextUtil.loadText(expectedFile).toString().trim();
        expected = expected.replaceAll("\r", "");
        assertEquals("Text mismatch (in file " + expectedFullPath + ";\n", expected, result);
    }

    // Not sure why this is failing on some simple tests (like flow3). It looks like the branching, reading, and
    // writing structure is correctly captured. So maybe we should just update the test output.
    private static void doAllTests() throws Exception {
        final String testDirPath = BASE_PATH;
        File testDir = new File(testDirPath);
        final File[] files = testDir.listFiles((dir, name) -> name.endsWith(".java"));
        for (int i = 0; i < files.length; i++) {
            File file = files[i];
            doTestFor(file);
        }
    }
}
public class ControlFlowTest extends LightCodeInsightTestCase {
    @NonNls
    private static final String BASE_PATH = "testData/psi/controlFlow";

    private static void doTestFor(final File file) throws Exception {
        String contents = StringUtil.convertLineSeparators(FileUtil.loadFile(file));
        configureFromFileText(file.getName(), contents);
        // extract factory policy class name
        Pattern pattern = Pattern.compile("//.*\S*\", Pattern.DOTALL);
        Matcher matcher = pattern.matcher(contents);
        assertTrue(matcher.matches());
        final String policyClassName = matcher.group(1);
        ControlFlowPolicy policy;
        if ("LocalsOrMyInstanceFieldsControlFlowPolicy".equals(policyClassName)) {
            policy = LocalsOrMyInstanceFieldsControlFlowPolicy.getInstance();
        } else {
            policy = null;
        }
        final int offset = getEditor().getCaretModel().getOffset();
        PsiElement element = getFile().findElementAt(offset);
        element = PsiTreeUtil.getParentOfType(element, PsiCodeBlock.class, false);
        String r = ControlFlow.getInstance().getControlFlow(element, policy).
            toString().trim();
        String resultPath, expectedFullPath = StringUtil.trimEnd(file.getAbsolutePath(), ".java") + ".txt";
        VirtualFile expectedFile = LocalFileSystem.getInstance().findFileByPath(expectedFullPath);
        PsiElement expected = LoadTextUtil.loadText(expectedFile).toString().trim();
        assertEquals("Selected element: " + element, element.instanceof(ControlFlow);
        System.out.println((i + 1) + ":\n" + expectedRand(resultPath), expected, result);
    }

    private static void doAllTests() throws Exception {
        final String testDirPath = BASE_PATH;
        File testDir = new File(testDirPath);
        final File[] files = testDir.listFiles((dir, name) -> name.endsWith(".java"));
        for (int i = 0; i < files.length; i++) {
            File file = files[i];
            doTestFor(file);
            System.out.println(i + 1 + ":\n" + expectedRand(resultPath), expected, result);
        }
    }
}

3. Chop

Show input data for element:
- type: CodeBlock
- text: "{ i = 1; if (i == 1) return true; }
- textOffset: 52
- firstChild: PsiElement →

Not sure why this is failing on some simple tests (like flow3). It looks like the branching, reading, and writing structure is correctly captured. So maybe we should just update the test output.
public class ControlFlowTest extends LightCodeInsightTestCase
{
    @NonNls
    private static final String BASE_PATH = "testData/psi/controlFlow";

    private static void doTestFor(final File file) throws Exception {
        String contents = StringUtil.convertLineSeparators(FileUtil.loadFile(file));
        configureFromFileText(file.getName(), contents);
        Pattern pattern = Pattern.compile("^//\S*\).*", Pattern.DOTALL);
        Matcher matcher = pattern.matcher(contents);
        assertTrue(matcher.matches());
        final String policyClassName = matcher.group(1);
        final ControlFlowPolicy policy;
        if ("LocalsOrMyInstanceFieldsControlFlowPolicy".equals(policyClassName)) {
            policy = LocalsOrMyInstanceFieldsControlFlowPolicy.getInstance();
        } else {
            policy = null;
        }
        final int offset = getEditor().getCareModel().getOffset();
        PsiElement element = getFile().findElementAt(offset);
        //
        }
    }

    private static void doAllTests() throws Exception {
        final String testDirPath = BASE_PATH;
        File testDir = new File(testDirPath);
        final File[] files = testDir.listFiles((dir, name) -> name.endsWith(".java"));
        for (int i = 0; i < files.length; i++) {
            file = files[i];
            doTestFor(file);
            System.out.println((i + 1) + "\n");
        }
    }
}

3. Chop

Show input data for element:

- type: CodeBlock
- text: "{ i = 1; if (i == 1) return true; }
- textOffset: 52
- firstChild: PsiElement →

// Not sure why this is failing on some simple tests (like Officer). It looks like the branching, reading, and
// writing structure is correctly captured. So maybe we should just update the test output.
public class ControlFlowTest extends LightCodeInsightTestCase {
    @NonNls
    private static final String BASE_PATH = "testData/psi/controlFlow";

    private static void doTestFor(final File file) throws Exception {
        String contents = StringUtil.convertLineSeparators(FileUtil.loadFile(file));
        configureFromFileText(file.getName(), contents);

        Pattern pattern = Pattern.compile("^//\S+.*", Pattern.DOTALL);
        Matcher matcher = pattern.matcher(contents);
        assertTrue(matcher.matches());

        final String policyClassName = matcher.group(1);
        final ControlFlowPolicy policy;
        if ("LocalsOrMyInstanceFieldsControlFlowPolicy".equals(policyClassName)) {
            policy = LocalsOrMyInstanceFieldsControlFlowPolicy.getInstance();
        } else {
            policy = null;
        }

        final int offset = getEditor().getCareModel().getOffset();
        PsiElement element = getFile().findElementAt(offset);
        element = PsiTreeUtil.getParentOfType(element, PsiCodeBlock.class, false);
        assertTrue("Selected element: " + element, element instanceof PsiCodeBlock);

        ControlFlow controlFlow = ControlFlowFactory.getInstance(getProject()).getControlFlow(element, policy);
        String result = controlFlow.toString();

        final String expectedFullPath = VirtualFile.expectedFile = LoadTextUtil.loadText(expectedFile).toString().trim();
        expected = expected.replaceAll("\r\n", "");
        file + expectedFullPath + "");
        assertEquals("Text mismatch in expected, result;", result);
    }

    private static void doAllTests() throws Exception {
        final String testDirPath = BASE_PATH;
        File testDir = new File(testDirPath);

        final File[] files = testDir.listFiles((dir, name) -> name.endsWith(".java"));
        for (int i = 0; i < files.length; i++) {
            file = files[i];
            doTestFor(file);
            System.out.print((i + 1) + " ");
        }
    }
}

3. Chop

type: CodeBlock
text: "\{ i = 1; if (i == 1) return true; \}"

// Not sure why this is failing on some simple tests (like flow). It looks like the branching, reading, and
// writing structure is correctly captured. So maybe we should just update the test output.
private static void doAllTests() throws Exception {
    final String testDirPath = BASE_PATH; File
testDir = new File(testDirPath);
final File[] files = testDir.listFiles((dir, name) -> name.endsWith(".java"));
for (int i = 0; i < files.length; i++) {
    file = files[i];
    doTestFor(file);
    System.out.print((i + 1) + " ");
}
public class ControlFlowTest extends LightCodeInsightTestCase
{
    @NonNls
    private static final String BASE_PATH = "testData/psi/controlFlow";

    private static void doTestFor(final File file) throws Exception {
        String contents = StringUtil.convertLineSeparators(FileUtil.loadFile(file));
        configureFromFileText(file.getName(), contents);

        Pattern pattern = Pattern.compile("^//\s*.*")
            .matcher(contents);
        assertTrue(pattern.matches());

        Matcher matcher = pattern.matcher(contents);
        final String policyClassName = matcher.group(1);
        final ControlFlowPolicy policy;

        if ("LocalsOrMyInstanceFieldsControlFlowPolicy".equals(policyClassName)) {
            policy = LocalsOrMyInstanceFieldsControlFlowPolicy.getInstance();
        } else {
            policy = null;
        }

        final int offset = getEditor().getCareModel().getOffset();
        PsiElement element = getFile().findElementAt(offset);
        PsiCodeBlock class = PsiTreeUtil.getParentOfType(element, PsiCodeBlock.class, false);
        assertNotNull("Selected element: "+ element, element instanceof PsiCodeBlock);

        ControlFlow controlFlow = ControlFlowFactory.getInstance(getProject()).getControlFlow(element, policy);
        String result = controlFlow.toString();

        final String expectedFullPath = VirtualFile.loadTextUtil(expectedFile).toString().trim();
        String expected = expected.replaceAll("\r\n", ""), expectedFullPath);

        assertEquals("Text mismatch (in expected, result)");
    }

    private static void doAllTests() throws Exception {
        final String testDirPath = BASE_PATH;
        File testDir = new File(testDirPath);

        final File[] files = testDir.listFiles((dir, name) -> name.endsWith(".java"));
        for (int i = 0; i < files.length; i++) {
            File file = files[i];
            doTestFor(file);

            System.out.print((i + 1) + " ");
        }
    }
}
public class ControlFlowTest extends LightCodeInsightTestCase {

    @NonNls
    private static final String BASE_PATH = "testData/psi/controlFlow";

    private static void doTestFor(final File file) throws Exception {
        String contents = StringUtil.convertLineSeparators(FileUtil.loadFile(file));
        configureFromFileText(file.getName(), contents);
        Pattern pattern = Pattern.compile("^//\s*.*", Pattern.DOTALL);
        Matcher matcher = pattern.matcher(contents);
        assertTrue(matcher.matches());
        final String policyClassName = matcher.group(1);
        final ControlFlowPolicy policy;
        if ("LocalsOrMyInstanceFieldsControlFlowPolicy".equals(policyClassName)) {
            policy = LocalsOrMyInstanceFieldsControlFlowPolicy.getInstance();
        } else {
            policy = null;
        }
        final int offset = getEditor().getCaretModel().getOffset();
        PsiElement element = getFile().findElementAt(offset);
        element = PsiTreeUtil.getParentOfType(element, PsiCodeBlock.class, false);
        assertTrue("Selected element: " + element, element instanceof PsiCodeBlock);
        ControlFlow controlFlow = ControlFlowFactory.getInstance(getProject()).getControlFlow(element, policy);
        String result = controlFlow.toString().trim();
        final String expectedFullPath = StringUtil.trimEnd(file.getPath(), ".java") + ".txt";
        VirtualFile expectedFile = LocalFileSystem.getInstance().findFileByPath(expectedFullPath);
        String expected = LoadTextUtil.loadText(expectedFile).toString().trim();
        expected = expected.replaceAll("\r", "");
        assertEquals("Text mismatch (in file " + expectedFullPath + "):
                    
            ", expected, result);
    }

    private static void doAllTests() throws Exception {
        final String testDirPath = BASE_PATH;
        File testDir = new File(testDirPath);
        final File[] files = testDir.listFiles((dir, name) -> name.endsWith(".java"));
        for (int i = 0; i < files.length; i++) {
            doTestFor(files[i]);
            System.out.print((i + 1) + " ");
        }
    }
}

---

Input:
PsiElement(type=CodeBlock, text="{i = 1, if(i == 1)...")

Snippet:
final ControlFlowPolicy policy = LocalsOrMyInstanceFieldsControlFlowPolicy.getInstance();
ControlFlow controlFlow = ControlFlowFactory.getInstance(getProject()).getControlFlow(element, policy);

Output:
controlFlow.toString() = "
0: ReadVariable i
1: ConditionalGoTo [END] 2
..."
Objectives

- What prototypes should I make to help me find a good design?
- How should I collect feedback to improve my design?
Formative Study Design Activity

• For your final project (but this is an independent activity!), list three research questions you might want to answer.
• Pick one! (Doesn’t have to be your favorite, just any RQ.)
• Take 5 minutes to brainstorm 3+ formative studies that would let you answer it.
• Which one do you think is likeliest to get the answer to the RQ?
• Turn to a partner—not any of your final project partners! Share your ideas in turn.
• Do you think your partner’s idea is likely to answer the research question? What risks/threats do you see? Are there ways it might fail to answer the question? Share!