

# Title 3

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## 1 Introduction

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## 2 Background and Related Work

Software reuse is a broad term, that refers to the practice of reusing previously written code, rather than coding from scratch. It is one of the key practices of software engineering. It is in fact such an important part of software engineering, that one of the ways to measure the quality of software is by its ‘Reusability’[9] - i.e. the degree to which the application or its components can be reused. There are many different ways to do reuse in software engineering. Software libraries and frameworks are good examples of software that are intended to be reused. Developers may also scour the internet for things such as open-source software, or code snippets from websites like StackOverflow, which can be reused.

There are multiple benefits to software reuse, depending on how the reuse is performed. One example is saving time. Not only can the developer avoid spending time writing the syntax of the code, they may also be able to avoid figuring out the logic of the software, and testing the reused software (assuming the software is tested by its creator). Another benefit is found through modularity. By breaking down a software system into smaller modules, the logic behind features or functions can be contained within a module, and can be tested thoroughly.

Despite reuse being an important practice in software engineering, there is still a limited focus on this practice when it comes to low-code development platforms (LCDP). This lack of reuse focus can easily impact the so-called ‘Citizen Developers’, who have little or no coding knowledge, and may thus miss out on the benefits of reuse. A study from 2021 studied several low-code platforms (LCPs), in order to identify characteristic features of LCPs. The identified features were presented according to how frequent they occurred, with domain-specific reference artifacts being categorized as ‘rare’. Most studied systems offered catalogs of “reusable functions or examples of predefined processes”, but they were found to be generic, or have a limited scope[10]. There have been proposed some ideas on how to promote reuse for LCPs, such as the strongly-typed rich templating language OSTRICH, developed for the model-driven low-code platform OutSystems. OutSystems provides scaffolding mechanisms for common development patterns and sample screen templates, both designed by experts on domain-specific languages (DSL). The practice of using templates in the OutSystems platform involves cloning and modifying samples, which may require more knowledge than the end-user possesses. The goal of OSTRICH is to remove this need for adaptation when using templates, to remove the knowledge-barrier when making use of the available templates. This is done by abstracting and parameterizing the templates. A limitation of OSTRICH, is that it currently only supports the top nine most used production-ready screen templates from OutSystems. The end-user may not create and save their own templates, nor can they re-apply a template which they have customized.

Another approach focused on enabling model reuse by converting and merging heterogeneous models together into several graphs, which are then merged into one single graph (The Knowledge Graph), which acts as the repository of models. The Knowledge Graph can be queried to predict the next modeling step, based on the model being constructed by the user. This approach focuses on how to store, query, recommend and integrate the pre-defined models efficiently. End-Users can also persist their own models to the repository for later reuse.

For citizen developers, this feature of recommending models which have been constructed by domain experts and then

developed by model experts could prove very useful. However, while the user may persist their own models, the study is clearly not focused on guiding the user towards reusing their own models.

On the other hand, some existing LCDPs offer the user the ability to create their own models - for example by defining a new block in a block-based tool[39].

Building on the ideas discussed for improving reuse in low-code development platforms (LCDPs), several popular tools show these concepts in action. For instance, Webflow[32] is a leading low-code platform that offers a wealth of features for building responsive websites. One of its standout features is the ability to create reusable components and UI kits, which can significantly speed up the development process. With Webflow’s intuitive interface, developers can quickly design and prototype components, and then reuse them across multiple pages and projects.

In a similar way, Mendix[40] takes this further for full enterprise apps by offering shareable building blocks like simple actions (microflows) and UI parts that anyone on a team can grab and use again without recoding. Through its Marketplace, a free online hub, you can download ready templates, connectors for tools like Salesforce, and basic setups that fit right into new projects, making everything faster and more uniform. This approach builds on the flexibility seen in platforms like Webflow, but adds strong team tools and AI suggestions to spot and create reusable pieces, empowering even beginners to build complex apps while keeping reuse simple and widespread.

OutSystems[41] further enhances the concept of reuse in low-code development platforms by emphasizing rapid application delivery through its robust set of features. Like Webflow and Mendix, OutSystems also provides a library of reusable components and templates that help developers complete projects faster. Its user-friendly visual development environment allows users to easily drag and drop elements while connecting with existing systems. OutSystems also supports teamwork with built-in version control and feedback features, making it easy for teams to share and improve reusable components. Additionally, the platform uses AI to suggest the best solutions and components for specific tasks, helping to streamline the development process. By encouraging reuse at both individual and team levels, OutSystems enables organizations to create scalable applications quickly while ensuring quality and consistency.

Despite all of the useful features that these tools have, none of them provides guidance to the end-users to create custom reusable components which is the key feature of our project.

In order to analyze how block-based robotics environments address reuse area, 4 representative platforms were compared: mBlock, MakeCode, SPIKE LEGO, VEXcode GO and Open Roberta. The comparison focused on three main dimensions of reuse: structural reuse (through user-defined blocks or functions), social reuse (through sharing or remixing existing projects), and interoperable reuse (through import/export capabilities).

Table 1. Block Based Robotics Environments Reuse Support

Platform	Structural Reuse	Social Reuse	Interoperable Reuse	Reuse Support
VEXcode GO	X	X		Medium
mBlock	X	X	X	Medium
MakeCode	X	X	X	Medium
Spike Lego	X		X	Low
Open Roberta		X		Low

In this context, “reuse support” represents a scale that measures how effectively each platform facilitates reuse-related features. High reuse support indicates that users can easily create, share, and adapt existing components or projects.

Medium reuse support suggests that some reuse mechanisms are available but limited in scope or flexibility. Low reuse support implies that the platform provides only minimal or restricted features to promote reuse and improve user productivity.

As shown in Table 1, although these platforms include reusability features, they are quite limited, as none of them provide users with clear guidance on how to use these tools effectively, which restricts their ability to fully leverage them.

Research also indicates that block based programming environments should guide the end users towards good code organization as many may lack the necessary knowledge or may become stuck due to errors.[15] Although block based programming tools like Blockly were invented to teach programming to beginners by simple examples, Mayr-Dorn et al. mention that it is possible to express even large and highly complex real-world robot programs with the language concepts offered by these kind of block-based tools. [33]

Lin and Weintrop (2021) noted that most existing research on block-based programming focuses on supporting the transition to text-based languages rather than exploring how features within BBP environments [31]—such as abstraction or reuse—can enhance learning outcomes. In contrast, our work emphasizes guided abstraction, helping users understand and practice modular design directly within block-based environments.

Techapalokul and Tilevich (2019) proposed extending the Scratch programming environment with facilities for reusing individual custom blocks to promote procedural abstraction and improve code quality. They observed that while Scratch enables remixing of entire projects, it lacks mechanisms for reusing smaller, modular pieces of code. Their work suggests that supporting such fine-grained code reuse could enhance programmer productivity, creativity, and learning outcomes. Building on this idea, our project applies similar principles within the OpenRoberta environment by automating the detection of duplicate code segments and guiding users toward creating reusable custom blocks. Adler et al. (2021) introduced a search-based refactoring approach to improve the readability of Scratch programs by automatically applying small code transformations, such as simplifying control structures and splitting long scripts. Their findings demonstrated that automated refactoring can significantly enhance code quality and readability for novice programmers. Building upon this concept, our project applies similar principles in the OpenRoberta environment, focusing on detecting duplicate code segments and guiding users toward creating reusable custom blocks to promote modularity and abstraction.[3].

Existing block-based environments provide mechanisms for reuse, but lack intelligent support to help users recognize and apply reuse in practice.

To address this gap, our project introduces a guided reuse assistant within the Open Roberta Lab environment. The tool is designed to help users identify and apply reuse more easily while creating their robot programs. It works by automatically scanning a user’s block-based program to detect repeated code segments that appear in different parts of the workspace. Once these duplicates are found, the system highlights them visually, drawing the user’s attention to patterns that could be simplified.

When repeated blocks are detected, the assistant suggests creating a reusable custom block (function). It then helps the user generate this new block by identifying the small differences between the repeated parts—such as numbers, variables, or parameters—and turning these differences into inputs for the new block. After the user confirms, the system automatically replaces all the repeated sequences with calls to the newly created reusable block.

By combining ideas from procedural abstraction (organizing code into meaningful, reusable parts) and automated refactoring (improving code through intelligent transformations), our tool aims to make block-based programming

more structured and efficient. It encourages users to build programs that are modular and easier to maintain, helps reduce unnecessary repetition, and supports learning by making the concept of reuse clear and hands-on.

In summary, our work bridges the gap between existing theoretical approaches to software reuse and their real-world application in block-based programming environments. Through this guided and semi-automated approach, we aim to make reuse visible, understandable, and practical for end-users working in Open Roberta.

### 3 Study Design

#### 3.1 Problem Investigation

*3.1.1 Problem Context and Motivation.* End-user development (EUD) for collaborative robots (cobots) presents unique challenges, particularly for users without formal programming training. In domains such as chemistry laboratories, educational robotics, and industrial settings, end-users need to program robots to perform specific tasks but often lack the software engineering knowledge to write maintainable, well-structured code.

One critical challenge in EUD is code reuse. Users frequently create repetitive code because they struggle to recognize duplicate patterns, lack knowledge about abstraction mechanisms, or find existing tools too complex to use effectively. This problem manifests in several ways: programs become unnecessarily long and difficult to maintain, small changes require modifications in multiple locations increasing the risk of errors, and users miss opportunities to learn fundamental programming concepts such as modularity and abstraction.

In visual programming environments like Open Roberta Lab, don't provide assistance in identifying when code should be reused or how to extract repeated sequences into reusable components.

##### *3.1.2 Stakeholder Analysis.*

- **Chemistry Laboratory Personnel:** Chemists and lab technicians who use cobots for repetitive tasks such as sample preparation, dispensing, mixing, and quality control procedures. They possess deep domain expertise in chemistry but limited programming knowledge, often creating long, repetitive programs that become difficult to maintain when adapting experimental protocols. Their primary need is to quickly create and modify robot programs without becoming programming experts.

Table 2. Functional and Non-Functional Requirements

Type	ID	Description	Priority
Functional	FR1	Detect duplicate/similar block sequences	High
	FR2	Visually highlight detected duplications	High
	FR3	Suggest creation of reusable custom blocks	High
	FR4	Allow users to accept/reject suggestions	High
Non-Functional	NFR1	Seamless Open Roberta Lab integration	High
	NFR2	Intuitive interface for end users	High
	NFR3	No interference with existing workflow	High
	NFR4	Clear visual feedback during detection	High

##### *3.1.3 Artifact Requirements.*

## 3.2 Treatment Design

Our treatment focuses on developing a guided reuse assistant for the OpenRoberta Lab environment. The purpose of this tool is to help users recognize when parts of their robot programs can be reused, and to make it easier for them to create reusable custom blocks. By doing this, we aim to reduce repetitive code and help users learn important programming concepts such as modularity and abstraction.

*3.2.1 Overview of the Tool.* The guided reuse assistant is built as an extension inside Open Roberta Lab, which uses the Blockly framework. The assistant runs directly in the web browser and interacts with the user's block workspace. Its main job is to look through the user's program, find repeated sequences of blocks, and guide the user in turning them into reusable blocks.

The tool works in three main steps:

- (1) **Detecting Repeated Code:** The assistant automatically scans the user's program and searches for parts that look the same or very similar. These are marked as potential duplicates.
- (2) **Highlighting and Suggesting Reuse:** Once duplicates are found, the system highlights them in the workspace and shows a message suggesting that these sections could be made into a reusable block (function). This helps users see repetition they might not have noticed before.
- (3) **Helping the User Create a New Block:** If the user agrees to the suggestion, the assistant opens a small guide to help them create the new block. It automatically detects any small differences between the repeated parts, such as numbers or variable names, and turns them into inputs (parameters) for the new block. When the block is created, repeated code is replaced by the new reusable block.

## 3.3 Treatment Validation

The treatment validation for this study adopts a mixed-methods evaluation approach to assess the effectiveness of the proposed features for guiding users in creating reusable custom blocks within the OpenRoberta environment. Participants will be recruited from local educational institutions, specifically chemistry students and teachers who frequently engage in laboratory work. A sufficient number of (x) participants will be selected to ensure a diverse range of experience levels with block-based programming. The experimental setup will take place in a controlled environment, where participants will be divided into two groups: one using the enhanced OpenRoberta platform with guided block creation features, and the other using the standard version without these enhancements. The procedure will begin with a pre-test to evaluate participants' prior understanding of modular programming concepts, followed by a series of tasks in which they will create reusable blocks from given code segments. Participants' interactions with the platform will be observed throughout the experiment. Data collection will include both quantitative measures, such as task completion time and accuracy in creating reusable blocks and qualitative feedback obtained through post-task interview. The analysis will compare performance metrics between the two groups and apply thematic analysis to the qualitative data to identify user experiences and perceptions of the new features' usability and effectiveness. This comprehensive evaluation will provide a detailed understanding of how useful and effective is the block creation guidance feature to the end-users.

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This is a subsection.

*10.1.1 Subsubsection.* This is a subsubsection.

*Paragraph.* This is a paragraph.

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Table 3. Frequency of Special Characters

Non-English or Math	Frequency	Comments
Ø	1 in 1,000	For Swedish names
$\pi$	1 in 5	Common in math
\$	4 in 5	Used in business
$\Psi_1^2$	1 in 40,000	Unexplained usage

Table 4. Some Typical Commands

Command	A Number	Comments
<code>\author</code>	100	Author
<code>\table</code>	300	For tables
<code>\table*</code>	400	For wider tables

Subparagraph This is a subparagraph.

## 11 Tables

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Table captions are placed *above* the table.

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## 12.2 Display Equations

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$$\lim_{n \rightarrow \infty} x = 0 \tag{1}$$

Notice how it is formatted somewhat differently in the **displaymath** environment. Now, we'll enter an unnumbered equation:

$$\sum_{i=0}^{\infty} x + 1$$

and follow it with another numbered equation:

$$\sum_{i=0}^{\infty} x_i = \int_0^{\pi+2} f \tag{2}$$

just to demonstrate  $\text{\LaTeX}$ 's able handling of numbering.

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Fig. 1. 1907 Franklin Model D roadster. Photograph by Harris & Ewing, Inc. [Public domain], via Wikimedia Commons. (<https://goo.gl/VLCRBB>).

```
\begin{teaserfigure}
  \includegraphics[width=\textwidth]{sampleteaser}
  \caption{figure caption}
  \Description{figure description}
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```

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## 16 Appendices

If your work needs an appendix, add it before the “\end{document}” command at the conclusion of your source document.

Start the appendix with the “appendix” command:

```

620 \appendix
621

```

and note that in the appendix, sections are lettered, not numbered. This document has two appendices, demonstrating the section and subsection identification method.

## 17 Multi-language papers

Papers may be written in languages other than English or include titles, subtitles, keywords and abstracts in different languages (as a rule, a paper in a language other than English should include an English title and an English abstract). Use `language=...` for every language used in the paper. The last language indicated is the main language of the paper. For example, a French paper with additional titles and abstracts in English and German may start with the following command

```
\documentclass[sigconf, language=english, language=german,
                language=french]{acmart}
```

The title, subtitle, keywords and abstract will be typeset in the main language of the paper. The commands `\translatedXXX`, `XXX` begin title, subtitle and keywords, can be used to set these elements in the other languages. The environment `translatedabstract` is used to set the translation of the abstract. These commands and environment have a mandatory first argument: the language of the second argument. See `sample-sigconf-i13n.tex` file for examples of their usage.

## 18 SIGCHI Extended Abstracts

The “sigchi-a” template style (available only in  $\text{\LaTeX}$  and not in Word) produces a landscape-orientation formatted article, with a wide left margin. Three environments are available for use with the “sigchi-a” template style, and produce formatted output in the margin:

**sidebar:** Place formatted text in the margin.

**marginfigure:** Place a figure in the margin.

**marginfigure:** Place a table in the margin.

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## A Research Methods

### A.1 Part One

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### A.2 Part Two

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## B Online Resources

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