

1 Title 3

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9 Additional Key Words and Phrases: Do, Not, Use, This, Code, Put, the, Correct, Terms, for, Your, Paper

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14 1 Introduction

15 2 Background and Related Work

16 Software reuse is a broad term, that refers to the practice of reusing previously written code, rather than coding from scratch. It is such an important part of software engineering, that one of the ways to measure the quality of software is by it's 'Reusability'^[9] - i.e. the degree to which the application or its components can be reused. There are multiple benefits to practicing reuse in software engineering. One developer could save time by using another developer's reusable component, rather than coding their own. The developer avoids both the work of writing the syntax and designing the logic of the component. The developer can design their own reusable components, keeping all the logic in one place, which can then be tested thoroughly. However, 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).

17 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

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processes", but they were found to be generic, or have a limited scope[10]. This lack of focus on promoting reuse may impact the so-called 'Citizen Developers', who have little or no coding knowledge, and whom may then miss out on the benefits of reuse.

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[31]. 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 reuse of models, by converting and merging models into a single graph (the Knowledge Graph), which acts as a repository of models[24]. This graph is used to provide recommendations to the end-user, based on the model they're currently building. While this feature of recommending models (either constructed by domain experts and then developed by model experts, or made by the end-user themselves) could prove very useful, the study is clearly not focused on guiding the user towards reusing their own models.

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. Despite all of the useful features that this tool has, it does not provide guidance to the end-users to create custom reusable components.

In a similar way, Mendix[38] 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. This tool does offer guidance for the end-users to create custom reusable components through its AI suggestions, a lot of times these suggestions are not accurate enough (how do we know this??*).

OutSystems[39] 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. By encouraging reuse at both individual and team levels, OutSystems enables organizations to create scalable applications quickly while ensuring quality and consistency. Similarly to the previous tool explained, the AI suggestions that this tool provides are not always accurate to successfully guide the end-user to create custom reusable components (again, how do we know this??*).

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.

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 [30]—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

157 programs. It works by automatically scanning a user's block-based program to detect repeated code segments in the
158 workspace. The system visually highlights the found duplicates, drawing the user's attention to patterns that could be
159 simplified.
160

161 The tool also offers the functionality to create the custom block for the end-user, by identifying the small differences
162 between the repeated parts—such as numbers, variables, or parameters—and turning these differences into inputs for
163 the new block. The tool automatically replaces all relevant duplicate sequences with the new custom block.
164

165 By combining ideas from procedural abstraction (organizing code into meaningful, reusable parts) and automated
166 refactoring (improving code through intelligent transformations), our tool aims to make block-based programming
167 more structured and efficient. It encourages users to build programs that are modular and easier to maintain, helps
168 reduce unnecessary repetition, and supports learning by making the concept of reuse clear and hands-on.
169

170 171 3 Study Design

172 3.1 Problem Investigation

173 3.1.1 *Problem Context and Motivation.* End-user development (EUD) for collaborative robots (cobots) presents unique
174 challenges, particularly for users without formal programming training. In domains such as chemistry laboratories,
175 educational robotics, and industrial settings, end-users need to program robots to perform specific tasks but often lack
176 the software engineering knowledge to write maintainable, well-structured code. In the domain of Chemistry, one of
177 the most prevalent and important tasks is performing experiments in labs in order to test a hypothesis, or to aid in the
178 understanding of how chemicals react. Robots can be used in chemistry labs to automate experiments with great effect,
179 as many experiments involve steps that are repetitive, and susceptible to human error - such as a step being overlooked,
180 instructions being misread, etc. Automation of menial tasks will leave the chemists with more time for other work, and
181 also comes with the added bonus of chemists not having to handle dangerous chemicals.
182

183 One critical challenge in EUD is code reuse. Users frequently create repetitive code because they struggle to recognize
184 duplicate patterns, lack knowledge about abstraction mechanisms, or find existing tools too complex to use effectively.
185 This problem manifests in several ways: programs become unnecessarily long and difficult to maintain and small changes
186 require modifications in multiple locations, increasing the risk of errors. Several visual programming environments,
187 like OpenRoberta Lab, don't provide assistance in identifying when code should be reused or how to extract repeated
188 sequences into reusable components. As lab work in chemistry involves many repetitive tasks, these challenges can
189 easily become an obstacle for the chemists, which may turn them away from using cobots, as the inconvenience
190 outweighs the benefits.
191

192 3.1.2 Stakeholder Analysis.

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201 • **Chemistry Laboratory Personnel:** Chemists and lab technicians who use cobots for repetitive tasks such as
202 sample preparation, dispensing, mixing, and quality control procedures. They possess deep domain expertise in
203 chemistry but limited programming knowledge, often creating long, repetitive programs that become difficult
204 to maintain when adapting experimental protocols. Their primary need is to quickly create and modify robot
205 programs without becoming programming experts.
206
207

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.* The artifact requirements can be seen in table 2.

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 which 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 custom reusable components (blocks) within the OpenRoberta environment.

261 3.3.1 Participant Recruitment. A total of 10 participants will be selected to ensure a diverse range of experience levels
262 with block-based programming. Time constraints and resource availability have influenced the decision to limit the
263 number of participants. Participants will be recruited from a diverse pool of individuals affiliated with the University
264 of Southern Denmark and the broader chemistry community. This group of participants includes chemistry teachers,
265 professional chemical engineers, and students currently enrolled in chemistry-intensive curricula. To ensure relevant
266 practical expertise, the selection specifically targets those who frequently engage in laboratory environments. The
267 experimental sessions will be conducted across a range of environments to accommodate participant availability.
268 Physical sessions will take place within the chemistry laboratories at the University of Southern Denmark (SDU) as
269 well as a private residential setting. For remote participants, sessions will be administered virtually using Discord for
270 communication and AnyDesk for remote desktop control.
271

272 274 Ethical Considerations and Sampling. Prior to the commencement of the study, all participants are required to sign a
275 consent form acknowledging their voluntary participation and granting permission for screen recording and data usage.
276 It should be noted that this recruitment strategy constitutes *convenience sampling*. As such, they may not represent the
277 general population.
278

279 280 3.3.2 Task Execution. The participants will initially be given a short introduction to the OpenRoberta UI, as well
281 as the mujoco robot simulator. They will then perform one task which is described by a set of pre-defined steps to
282 perform. This task has been specifically designed to promote the reusability aspect. The task is focused on the domain
283 of chemistry, as it is modelled after a real lab experiment performed by chemistry students at SDU.
284

285 The participants will be instructed to program the robot to execute the following sequence of operations:
286

- 287 (1) Move the robot arm above mix cylinder*
- 288 (2) Mix the chemistry ingredients*
- 289 (3) Move the robot arm above the analysis pad*
- 290 (4) Analyze the sample*
- 291 (5) If the solution is analyzed (use if statement) then show a response message in the laptop's screen*
- 292 (6) Place the following three objects into their corresponding slots in the chemistry equipment toolbox:*
 - 293 • Methanol cylinder*
 - 294 • Chloroform syringe*
 - 295 • Toluene syringe*
- 296 (7) Important notes for the participants:*
 - 297 • After placing an object to its slot in the toolbox **wait 2 seconds** before you move to pick a new one.*
 - 298 • After placing the **chloroform syringe** to its slot, **move the robot arm up by 10 cm** before you move to pick
*299 the next chemistry object**
 - 300 • Click the **play button** on the bottom right corner to start the simulation*
 - 301 • Click the **reset button** on the bottom right corner to reset the scene of the robot simulator*

302 306 Most optimal solution pre-defined by the researchers:

*307 308 Instead of creating a long linear sequence of blocks (hard-coding the movement for all three objects), the most
309 optimal solution utilizes a **“Custom Reusable Component”** to handle the repetitive action of placing an object to its
310 corresponding slot inside the equipment toolbox. This approach not only reduces redundancy but also enhances code
311 maintainability and readability, aligning with best practices in software development.
*312**

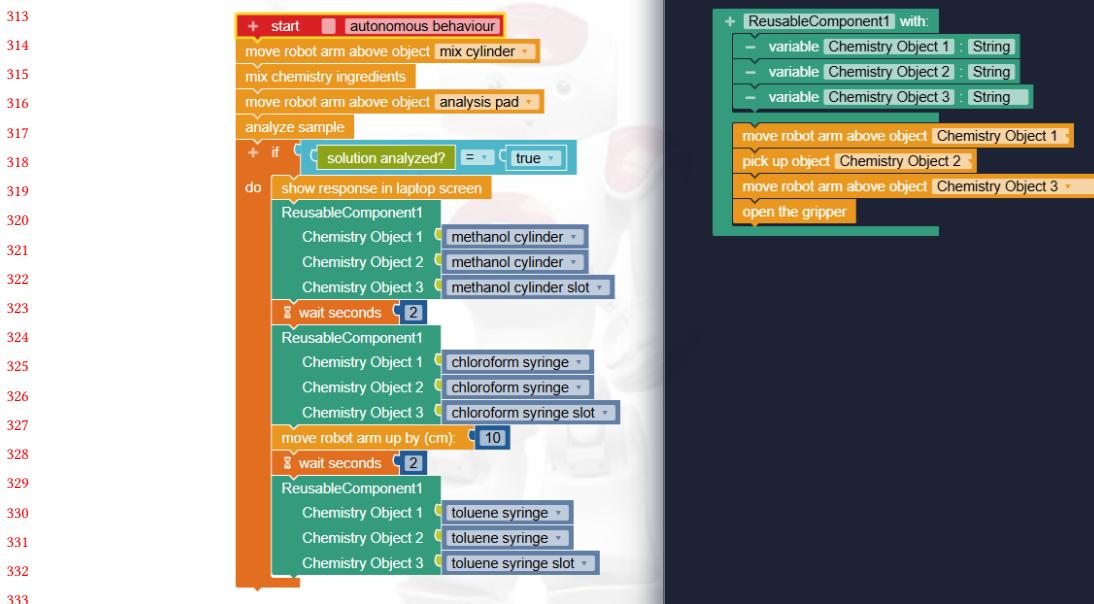


Fig. 1. The optimal solution implemented in OpenRoberta, utilizing a custom block for the object placement sequence.

All the participants will try to complete the task using both the standard and the enhanced version of OpenRoberta. Half of the participants will begin using the enhanced version of OpenRoberta, while the other half will start with the standard version. Participants' interactions with the platform will be observed throughout the task. Guidance will be provided from the researchers to the participants throughout the task.

3.3.3 Data Gathering and Analysis. Data collection focuses on both quantitative performance and qualitative feedback from participants:

- (1) **Task Completion Time:** Comparing the participants who will first use the enhanced version of OpenRoberta against those who will first use the standard version.
- (2) **Solution Accuracy:** Evaluated by comparing the participant's block configuration against the pre-defined optimal solution.
- (3) **Qualitative Feedback:** Collected via a post-experiment survey designed to capture demographic data and subjective perceptions of the utility of the block creation guidance features.

This comprehensive evaluation will provide a detailed understanding of how useful and effective is the block creation guidance feature to the end-users.

4 Results

The treatment validation was concluded with a total of 10 participants. The analysis of the collected data combines quantitative metrics regarding user preference and satisfaction with qualitative feedback derived from survey responses.

365 4.1 Performance Evaluation

366
367 To evaluate the efficiency and effectiveness of the proposed reusable component features, we analyzed two primary
368 metrics: Task Completion Time and Solution Accuracy.

369
370 **4.1.1 Task Completion Time.** The total time required to complete the experimental task was recorded for both the
371 *Standard* and *Enhanced* conditions.

372 We compared the performance of participants based on the order of conditions (see Table 3). The analysis reveals a
373 significant reduction in task duration when using the Enhanced version. The average completion time for the participants
374 that used the Enhanced version first was 8.5 minutes, compared to 10 minutes for the Standard version.

$$376 \quad 377 \quad \text{Efficiency Improvement} = \frac{10.0 - 8.5}{10.0} \times 100\% = 15\% \quad (1)$$

379
380 Table 3. Breakdown of Mean Task Completion Times
381

382 Experimental Condition	383 Mean Time (min)
384 Group of Participants that used the Enhanced OpenRoberta Version First	8.5
385 Group of Participants that used the Standard OpenRoberta Version First	10.0

386
387
388 **4.1.2 Solution Accuracy.** Solution accuracy was evaluated by comparing participant solutions against the optimal
389 reference solution defined in the treatment evaluation.
390

391 *Adoption of Reusable Blocks.* A key metric was the voluntary adoption of the custom reusable component. In the
392 *Enhanced* version, 10/10 participants successfully implemented a custom reusable block to handle the repetitive object
393 placement steps. In contrast, in the *Standard* condition, participants predominantly relied on linear, repetitive code
394 structures. Without the guidance features, none of them recognized the opportunity to create a reusable block.
395

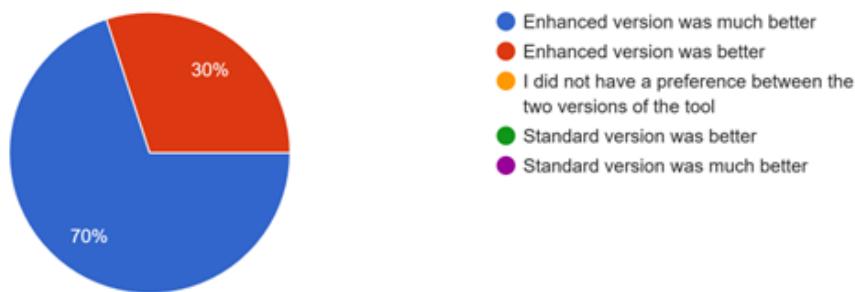
396 4.2 Survey Quantitative Results

397
398 **4.2.1 User preference between Standard and Enhanced Versions of OpenRoberta.** The survey results indicate a unanimous
399 preference for the enhanced version of the OpenRoberta Lab. As illustrated in Figure 2, 70% of participants rated the
400 enhanced version as “much better” than the standard version, while the remaining 30% rated it as “better.” No participants
401 preferred the standard version or rated the two versions as equivalent.
402

403
404 **4.2.2 Usability of the Guidance Feature.** Regarding usability of the enhanced OpenRoberta version, we received high
405 acceptance scores. As illustrated in Figure 3, 40% of participants found the enhanced version “very easy” to use, and
406 60% rated it as “easy.” No participants rated the enhanced version as “Neither easy nor difficult,” “Difficult,” or “Very
407 difficult” to use.
408

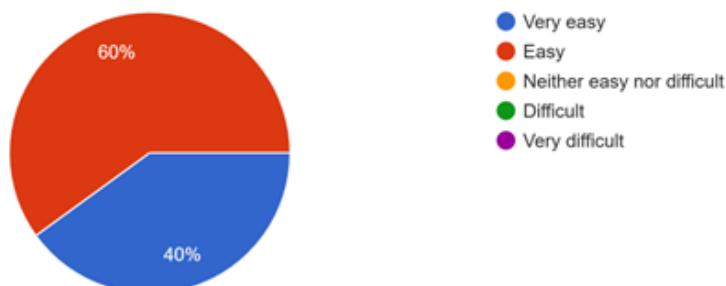
409
410 **4.2.3 Evaluation of the Visual Highlighting.** A key component of the enhanced version was the visual highlighting
411 designed to guide the user into an automatic custom reusable block creation. As shown in Figure 4, results showed a
412 high level of user satisfaction, with 90% of participants reporting they were either “satisfied” (20%) or “very satisfied”
413 (70%) with the features. Only one participant (10%) expressed a neutral stance.
414

417
418 Which version of the Open Roberta tool did you prefer overall?
419
420 10 responses



434 Fig. 2. Summary of participant responses regarding overall preference between the standard and enhanced versions of OpenRoberta
435
436
437

438 How easy it was for you to use the enhanced version of the Open Roberta tool?
439
440 10 responses



454 Fig. 3. Summary of participant responses regarding overall preference between the standard and enhanced versions of OpenRoberta
455
456
457

458 *4.2.4 Visual Highlighting Style Preference.* When asked about specific highlighting preferences, as depicted in Figure 459 the *Animated Color Highlight* was the most popular choice, preferred by 50% of the users. A significant portion of 460 participants (30%) expressed no strong preference between the styles, suggesting that the presence of guidance was 461 more important than the specific animation style used.
462

463 4.3 Qualitative Feedback

464 The post-experiment survey included open-ended questions to gather detailed feedback. The thematic analysis of these 465 responses revealed two primary findings:
466

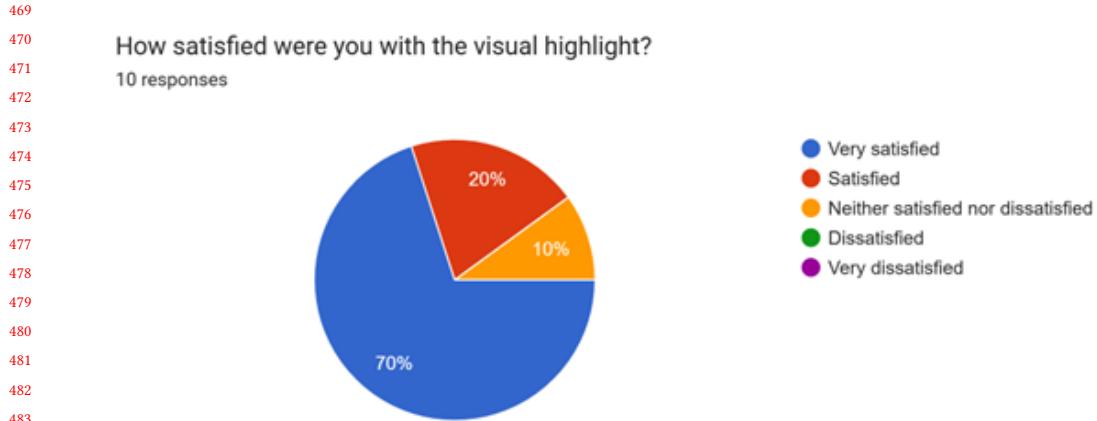


Fig. 4. Summary of participant responses regarding overall preference between the standard and enhanced versions of OpenRoberta

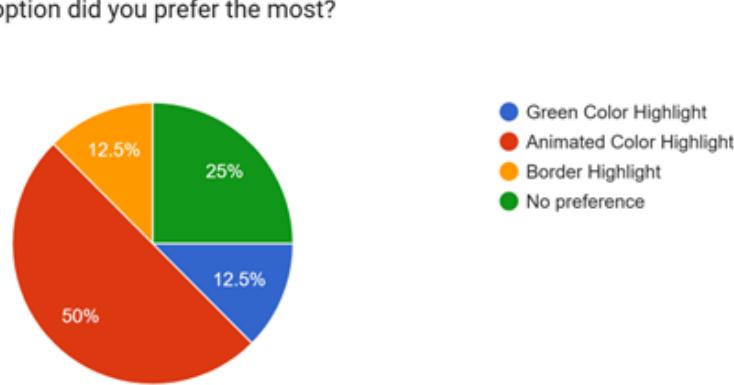


Fig. 5. Summary of participant responses regarding overall preference between the standard and enhanced versions of OpenRoberta

Efficiency and Speed. When asked to identify the biggest difference between the two versions, the majority of participants cited *efficiency*. Responses frequently described the enhanced version as “faster” and noted that it “saved a lot of time.” This aligns with the quantitative preference data, suggesting that the usability features successfully reduced the perceived workload.

Suggestions for Improvement. Participants also provided constructive feedback regarding the function blocks. Two participants specifically suggested that the system should more clearly “specify parameter names” within the function blocks to improve clarity. Another participant noted that the function call block should be pre-configured for immediate use in the blockchain. These suggestions highlight a need for clearer labeling in future iterations of the interface.

521 5 Discussion**522 5.1 Lessons Learned**

524 Based on the feedback from the participants, as well as observations of how they solved the task, the participants found
525 the enhanced version of OpenRoberta Lab to be better than the standard version. Noteably, 7 out of 8 participants
526 commented on how the enhanced version let them perform their task faster. As described in section 2, this is also one of
527 the main benefits of reuse in the field of software engineering. While a somewhat large(?) percentage of the participants
528 had no preference in regards to the visual look of the highlight, half of the users picked the 'Animated Color Highlight'.
529 This suggests that dynamic visuals - in this case: the blocks changing color repeatedly - are well-suited for catching the
530 user's attention.

531 Changes suggested by the participants mainly focus on smaller customizations of the tool and the OpenRoberta
532 Lab UI. It would be amiss to claim that the lack of suggested changes, focused on the tool overall, indicate that there
533 is no need for improvement of the tool. As many of the participants consider themselves 'beginners' in regards to
534 Computer Programming, it's likely that they lack ideas about other ways the tool could have been designed. Instead,
535 these answers can be interpreted as the participants having little to no issue with the current design.

540 5.2 Implications for Practice**541 5.3 Threats to Validity**

543 5.3.1 *Convenience Sampling*. The participants to the study were either acquaintances of one of the authors of the study,
544 or were recruited through these acquaintances. As such, the results of this study do not represent the general population
545 within the domain of chemistry.

547 5.3.2 *Limitations to observation*. Due to constraints with time and flexibility, only one of the authors was present to
548 observe the participants. To ensure that data from the observation was not affected by this, a screen recording of each
549 participant performing the task was saved. Several of the authors reviewed and discussed these recordings together to
550 extract data.

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 585
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 588

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 618 For example, a French paper with additional titles and abstracts in English and German may start with the following
 619 command
 620

```

    621 \documentclass[sigconf, language=english, language=german,
  
```

622 Manuscript submitted to ACM
 623
 624

625 `language=french]{acmart}`
 626
 627 The title, subtitle, keywords and abstract will be typeset in the main language of the paper. The commands
 628 \translatedXXX, XXX begin title, subtitle and keywords, can be used to set these elements in the other languages. The
 629 environment `translatedabstract` is used to set the translation of the abstract. These commands and environment have
 630 a mandatory first argument: the language of the second argument. See `sample-sigconf-i13n.tex` file for examples of
 631 their usage.
 632
 633

634 10 SIGCHI Extended Abstracts

635 The “sigchi-a” template style (available only in L^AT_EX and not in Word) produces a landscape-orientation formatted
 636 article, with a wide left margin. Three environments are available for use with the “sigchi-a” template style, and
 637 produce formatted output in the margin:
 638
 639

- 640 **sidebar:** Place formatted text in the margin.
- 641 **marginfigure:** Place a figure in the margin.
- 642 **margintable:** Place a table in the margin.

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645 References

- 646 [1] Rafal Abramowicz and Bertfried Fauser. 2007. *CLIFFORD: a Maple 11 Package for Clifford Algebra Computations, version 11*. Retrieved February 28, 2008 from <http://math.tntech.edu/rafal/cliff1/index.html>
- 647 [2] Patricia S. Abril and Robert Plant. 2007. The patent holder’s dilemma: Buy, sell, or troll? *Commun. ACM* 50, 1 (Jan. 2007), 36–44. doi:[10.1145/1188913.1188915](https://doi.org/10.1145/1188913.1188915)
- 648 [3] Felix Adler, Gordon Fraser, Eva Gründinger, Nina Körber, Simon Labrenz, Jonas Lerchenberger, Stephan Lukasczyk, and Sebastian Schweikl. 2021. Improving Readability of Scratch Programs with Search-Based Refactoring. In *Proceedings of the IEEE/ACM 43rd International Conference on Software Engineering: Companion Proceedings (ICSE-SEET)*. IEEE. doi:[10.1109/ICSE-Companion.2021.00105](https://doi.org/10.1109/ICSE-Companion.2021.00105)
- 649 [4] Sten Andler. 1979. Predicate Path expressions. In *Proceedings of the 6th ACM SIGACT-SIGPLAN symposium on Principles of Programming Languages (POPL ’79)*. ACM Press, New York, NY, 226–236. doi:[10.1145/567752.567774](https://doi.org/10.1145/567752.567774)
- 650 [5] David A. Anisi. 2003. *Optimal Motion Control of a Ground Vehicle*. Master’s thesis. Royal Institute of Technology (KTH), Stockholm, Sweden.
- 651 [6] Sam Anzaroot and Andrew McCallum. 2013. *UMass Citation Field Extraction Dataset*. Retrieved May 27, 2019 from <http://www.iesl.cs.umass.edu/data/data-umasscitationfield>
- 652 [7] Sam Anzaroot, Alexandre Passos, David Belanger, and Andrew McCallum. 2014. *Learning Soft Linear Constraints with Application to Citation Field Extraction*. arXiv:[1403.1349](https://arxiv.org/abs/1403.1349) doi:[10.48550/arXiv.1403.1349](https://doi.org/10.48550/arXiv.1403.1349)
- 653 [8] R. Baggett, M. Simecek, C. Chambellan, K. Tsui, and M. Fraune. 2025. Fluidity in the Phased Framework of Technology Acceptance: Case Study to Gain a Holistic Understanding of (Older Adult) Participant Advancement Through Acceptance Phases with Mobile Telepresence Robots. *Robotics Aut. Systems*. Manuscript submitted for review.
- 654 [9] Len Bass, Paul Clements, and Rick Kazman. 2021. *Software Architecture in Practice, 4th Edition*. Addison-Wesley Professional.
- 655 [10] Alexander Bock and Ulrich Frank. 2021. Low-Code Platform. *Business and Information Systems Engineering* 63 (2021). doi:[10.1007/s12599-021-00726-8](https://doi.org/10.1007/s12599-021-00726-8)
- 656 [11] Lutz Bornmann, K. Brad Wray, and Robin Haunschild. 2019. *Citation concept analysis (CCA)—A new form of citation analysis revealing the usefulness of concepts for other researchers illustrated by two exemplary case studies including classic books by Thomas S. Kuhn and Karl R. Popper*. arXiv:[1905.12410](https://arxiv.org/abs/1905.12410) [cs.DL]
- 657 [12] Kenneth L. Clarkson. 1985. *Algorithms for Closest-Point Problems (Computational Geometry)*. Ph.D. Dissertation. Stanford University, Palo Alto, CA. UMI Order Number: AAT 8506171.
- 658 [13] Jacques Cohen (Ed.). 1996. Special issue: Digital Libraries. *Commun. ACM* 39, 11 (Nov. 1996).
- 659 [14] Sarah Cohen, Werner Nutt, and Yehoshua Sagiv. 2007. Deciding equivalences among conjunctive aggregate queries. *J. ACM* 54, 2, Article 5 (April 2007), 50 pages. doi:[10.1145/1219092.1219093](https://doi.org/10.1145/1219092.1219093)

- [677] [15] Bruce P. Douglass, David Harel, and Mark B. Trakhtenbrot. 1998. Statecharts in use: structured analysis and object-orientation. In *Lectures on Embedded Systems*, Grzegorz Rozenberg and Frits W. Vaandrager (Eds.). Lecture Notes in Computer Science, Vol. 1494. Springer-Verlag, London, 368–394. doi:10.1007/3-540-65193-4_29
- [678] [16] Ian Editor (Ed.). 2007. *The title of book one* (1st. ed.). The name of the series one, Vol. 9. University of Chicago Press, Chicago, Chapter The title of the chapter, 127–238. doi:10.1007/3-540-09237-4
- [679] [17] Ian Editor (Ed.). 2008. *The title of book two* (2nd. ed.). University of Chicago Press, Chicago, Chapter 100, 25–137. doi:10.1007/3-540-09237-4
- [680] [18] Matthew Van Gundy, Davide Balzarotti, and Giovanni Vigna. 2007. Catch me, if you can: Evading network signatures with web-based polymorphic worms. In *Proceedings of the first USENIX workshop on Offensive Technologies (WOOT '07)*. USENIX Association, Berkley, CA, Article 7, 9 pages.
- [681] [19] Torben Hagerup, Kurt Mehlhorn, and J. Ian Munro. 1993. Maintaining Discrete Probability Distributions Optimally. In *Proceedings of the 20th International Colloquium on Automata, Languages and Programming (Lecture Notes in Computer Science, Vol. 700)*. Springer-Verlag, Berlin, 253–264.
- [682] [20] David Harel. 1978. *LOGICS of Programs: AXIOMATICs and DESCRIPTIVE POWER*. MIT Research Lab Technical Report TR-200. Massachusetts Institute of Technology, Cambridge, MA.
- [683] [21] David Harel. 1979. *First-Order Dynamic Logic*. Lecture Notes in Computer Science, Vol. 68. Springer-Verlag, New York, NY. doi:10.1007/3-540-09237-4
- [684] [22] Lars Hörmander. 1985. *The analysis of linear partial differential operators. III*. Grundlehren der Mathematischen Wissenschaften [Fundamental Principles of Mathematical Sciences], Vol. 275. Springer-Verlag, Berlin, Germany. viii+525 pages. Pseudodifferential operators.
- [685] [23] Lars Hörmander. 1985. *The analysis of linear partial differential operators. IV*. Grundlehren der Mathematischen Wissenschaften [Fundamental Principles of Mathematical Sciences], Vol. 275. Springer-Verlag, Berlin, Germany. viii+352 pages. Fourier integral operators.
- [686] [24] Ilirian Ibrahimi and Dimitris Moudios. 2022. Towards model reuse in low-code development platforms based on knowledge graphs. In *Proceedings of the 25th International Conference on Model Driven Engineering Languages and Systems: Companion Proceedings* (Montreal, Quebec, Canada) (MODELS '22). Association for Computing Machinery, New York, NY, USA, 826–836. doi:10.1145/3550356.3561570
- [687] [25] IEEE 2004. IEEE TCSC Executive Committee. In *Proceedings of the IEEE International Conference on Web Services (ICWS '04)*. IEEE Computer Society, Washington, DC, USA, 21–22. doi:10.1109/ICWS.2004.64
- [688] [26] Markus Kirschmer and John Voight. 2010. Algorithmic Enumeration of Ideal Classes for Quaternion Orders. *SIAM J. Comput.* 39, 5 (Jan. 2010), 1714–1747. doi:10.1137/080734467
- [689] [27] Donald E. Knuth. 1997. *The Art of Computer Programming, Vol. 1: Fundamental Algorithms* (3rd. ed.). Addison Wesley Longman Publishing Co., Inc., Boston.
- [690] [28] David Kosiur. 2001. *Understanding Policy-Based Networking* (2nd. ed.). Wiley, New York, NY.
- [691] [29] Newton Lee. 2005. Interview with Bill Kinder: January 13, 2005. Video. *Comput. Entertain.* 3, 1, Article 4 (Jan.-March 2005). doi:10.1145/1057270.1057278
- [692] [30] Yuhan Lin and David Weintrop. 2021. The Landscape of Block-Based Programming: Characteristics of Block-Based Environments and How They Support the Transition to Text-Based Programming. *Journal of Computer Languages* 67 (2021), 101075. doi:10.1016/j.jcola.2021.101075
- [693] [31] Hugo Lourenço, Carla Ferreira, and João Costa Seco. 2021. OSTRICH - A Type-Safe Template Language for Low-Code Development. In *2021 ACM/IEEE 24th International Conference on Model Driven Engineering Languages and Systems (MODELS)*. 216–226. doi:10.1109/MODELS50736.2021.00030
- [694] [32] Vlad Magdalin. 2012. Low code platform tool Webflow. <https://webflow.com/>.
- [695] [33] Dave Novak. 2003. Solder man. Video. In *ACM SIGGRAPH 2003 Video Review on Animation theater Program: Part I - Vol. 145 (July 27–27, 2003)*. ACM Press, New York, NY, 4. doi:10.945/woot07-S422 <http://video.google.com/videoplay?docid=6528042696351994555>
- [696] [34] Barack Obama. 2008. A more perfect union. Video. Retrieved March 21, 2008 from <http://video.google.com/videoplay?docid=6528042696351994555>
- [697] [35] Poker-Edge.Com. 2006. Stats and Analysis. Retrieved June 7, 2006 from <http://www.poker-edge.com/stats.php>
- [698] [36] R Core Team. 2019. *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria. <https://www.R-project.org/>
- [699] [37] Brian J. Reiser. 2014. Designing coherent storylines aligned with NGSS for the K-12 classroom. Presentation at National Science Education Leadership Association Meeting, Boston, MA, USA. <https://www.academia.edu/6884962/>
- [700] [38] Derek Roos. 2005. Low code platform tool Mendix. <https://www.mendix.com/>.
- [701] [39] Paulo Rosado. 2011. Low code platform tool Outsystems. <https://www.outsystems.com/>.
- [702] [40] Bernard Rous. 2008. The Enabling of Digital Libraries. *Digital Libraries* 12, 3, Article 5 (July 2008). To appear.
- [703] [41] Mehdi Saeedi, Morteza Saheb Zamani, and Mehdi Sedighi. 2010. A library-based synthesis methodology for reversible logic. *Microelectron. J.* 41, 4 (April 2010), 185–194.
- [704] [42] Mehdi Saeedi, Morteza Saheb Zamani, Mehdi Sedighi, and Zahra Sasanian. 2010. Synthesis of Reversible Circuit Using Cycle-Based Approach. *J. Emerg. Technol. Comput. Syst.* 6, 4 (Dec. 2010), 12 pages.
- [705] [43] Joseph Scientist. 2009. The fountain of youth. Patent No. 12345, Filed July 1st., 2008, Issued Aug. 9th., 2009.
- [706] [44] Stan W. Smith. 2010. An experiment in bibliographic mark-up: Parsing metadata for XML export. In *Proceedings of the 3rd. annual workshop on Librarians and Computers (LAC '10, Vol. 3)*, Reginald N. Smythe and Alexander Noble (Eds.). Paparazzi Press, Milan Italy, 422–431.
- [707] [45] Asad Z. Spector. 1990. Achieving application requirements. In *Distributed Systems* (2nd. ed.), Sape Mullender (Ed.). ACM Press, New York, NY, 19–33. doi:10.1145/90417.90738
- [708] [46] Harry Thorngburg. 2001. *Introduction to Bayesian Statistics*. Retrieved March 2, 2005 from <http://ccrma.stanford.edu/~jos/bayes/bayes.html>, archived at <https://web.archive.org/web/20240505055615/https://ccrma.stanford.edu/~jos/bayes/bayes.html>

- 729 [47] TUG 2017. *Institutional members of the TeX Users Group*. Retrieved May 27, 2017 from <http://www.tug.org/instmem.html>
730 [48] Boris Veytsman. 2017. *acmart—Class for typesetting publications of ACM*. Retrieved May 27, 2017 from <http://www.ctan.org/pkg/acmart>

731
732 **A Research Methods**

733 **A.1 Part One**

734 Lorem ipsum dolor sit amet, consectetur adipiscing elit. Morbi malesuada, quam in pulvinar varius, metus nunc
735 fermentum urna, id sollicitudin purus odio sit amet enim. Aliquam ullamcorper eu ipsum vel mollis. Curabitur quis
736 dictum nisl. Phasellus vel semper risus, et lacinia dolor. Integer ultricies commodo sem nec semper.

737
738 **A.2 Part Two**

739 Etiam commodo feugiat nisl pulvinar pellentesque. Etiam auctor sodales ligula, non varius nibh pulvinar semper.
740 Suspendisse nec lectus non ipsum convallis congue hendrerit vitae sapien. Donec at laoreet eros. Vivamus non purus
741 placerat, scelerisque diam eu, cursus ante. Etiam aliquam tortor auctor efficitur mattis.

742
743 **B Online Resources**

744 Nam id fermentum dui. Suspendisse sagittis tortor a nulla mollis, in pulvinar ex pretium. Sed interdum orci quis metus
745 euismod, et sagittis enim maximus. Vestibulum gravida massa ut felis suscipit congue. Quisque mattis elit a risus ultrices
746 commodo venenatis eget dui. Etiam sagittis eleifend elementum.

747 Nam interdum magna at lectus dignissim, ac dignissim lorem rhoncus. Maecenas eu arcu ac neque placerat aliquam.
748 Nunc pulvinar massa et mattis lacinia.

749
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