# Title 3

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CCS Concepts: • **Do Not Use This Code → Generate the Correct Terms for Your Paper**; *Generate the Correct Terms for Your Paper*; Generate the Correct Terms for Your Paper; Generate the Correct Terms for Your Paper.

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

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## 1 Introduction

ACM's consolidated article template, introduced in 2017, provides a consistent LaTeX style for use across ACM publications, and incorporates accessibility and metadata-extraction functionality necessary for future Digital Library endeavors. Numerous ACM and SIG-specific LaTeX templates have been examined, and their unique features incorporated into this single new template.

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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 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).

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 occured, 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]. 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[32]. 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 posseses. The goal of OSTRICH is to remove this need for adapation 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[33] 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 tools has, it does not provide guidance to the end-users to create custom reusable components.

In a similar way, Mendix[39] 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[40] 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 [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 in the workspace. The system visually highlights the found duplicates, drawing the user's attention to patterns that could be simplified.

The tool also offers the functionality to create the custom block for the end-user, 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. The tool automatically replaces all relevant duplicate sequences with the new custom 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.

## 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. In the domain of Chemistry, one of the most prevelant and important tasks is performing experiments in labs, in order to test a hypothesis, or to aid in the understanding of how chemicals react. Robots can be used in chemistry labs to automate experiments with great effect, as many experiments involve steps that are repetitive, and suspectible to human error - such as a step being overlooked, instructions being misread, etc. Using robots in labs also comes with the added bonus of chemists not having to handle dangerous chemicals.

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 and small changes require modifications in multiple locations, increasing the risk of errors. Several visual programming environments, like OpenRoberta Lab, don't provide assistance in identifying when code should be reused or how to extract repeated

sequences into reusable components. As lab work in chemistry involves many repetitive tasks, these challenges can easily become an obstacle for the chemists, which in turn may turn them away from using cobots, as the inconvenience outweighs the benefits.

*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 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

*3.3.1 Data Gathering and Analysis.* 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 survey to evaluate participants' prior understanding of modular programming concepts, followed by two tasks containing several repetitative steps, to make the user focus on reuse. 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. For the qualitative feedback, both groups will have to repeat the task, with the group that initially used the enhanced OpenRoberta platform now using the standard version, while the other group will use the enhanced version. 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.

*3.3.2 Task Execution.* Before the tasks, the participants will be given a short introduction to the OpenRoberta Lab, as well as the cobot simulator. The participants will then perform two tasks, each task described by a set of pre-defined steps to perform. The first task will be generic in nature. The purpose of this task is to make the user more familiar with block-based programming and the OpenRoberta Lab.

The second task is more focused on the domain of chemistry, as it is modelled after the instructions to a real lab experiment perfomed by chemistry students. The experiment instructions were obtained from one of the participants, and can be found in appendix XXX. The instructions for both tasks can be found in appendix XXX.

*3.3.3 Participant Recruitment.* The participants will be chemistry students and one supervisor from the University of Southern Denmark (SDU). One of the authors of this paper knows a student from the chemistry line, who was recruited and also assisted in recruiting others from his class.

The participants will be asked to fill out a survery before starting the tasks, in order to asses their background, as well as their knowledge about block-based programming, the use of cobots, OpenRoberta Lab and their experience with programming.

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Modifying the template — including but not limited to: adjusting margins, typeface sizes, line spacing, paragraph and list definitions, and the use of the `\vspace` command to manually adjust the vertical spacing between elements of your work — is not allowed.

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If your title is lengthy, you must define a short version to be used in the page headers, to prevent overlapping text. The `title` command has a "short title" parameter:

```
\title[short title]{full title}
```

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Each author must be defined separately for accurate metadata identification. As an exception, multiple authors may share one affiliation. Authors' names should not be abbreviated; use full first names wherever possible. Include authors' e-mail addresses whenever possible.

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```
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\email{dave,judy,steve@university.edu}
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```
\renewcommand{\shortauthors}{McCartney, et al.}
```

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The article template's documentation, available at https://www.acm.org/publications/proceedings-template, has a complete explanation of these commands and tips for their effective use.

Note that authors' addresses are mandatory for journal articles.

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The ACM Computing Classification System — https://www.acm.org/publications/class-2012 — is a set of classifiers and concepts that describe the computing discipline. Authors can select entries from this classification system, via https://dl.acm.org/ccs/ccs.cfm, and generate the commands to be included in the LaTeX source.

User-defined keywords are a comma-separated list of words and phrases of the authors' choosing, providing a more flexible way of describing the research being presented.

CCS concepts and user-defined keywords are required for for all articles over two pages in length, and are optional for one- and two-page articles (or abstracts).

## 10 Sectioning Commands

Your work should use standard LaTeX sectioning commands: `\section`, `\subsection`, `\subsubsection`, `\paragraph`, and `\subparagraph`. The sectioning levels up to `\subsusection` should be numbered; do not remove the numbering from the commands.

Simulating a sectioning command by setting the first word or words of a paragraph in boldface or italicized text is **not allowed.**

Below are examples of sectioning commands.

### 10.1 Subsection

This is a subsection.

*10.1.1 Subsubsection.* This is a subsubsection.

*Paragraph.* This is a paragraph.

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 |
|---|---|---|
| `\author` | 100 | Author |
| `\table` | 300 | For tables |
| `\table*` | 400 | For wider tables |

Subparagraph This is a subparagraph.

## 11 Tables

The "`acmart`" document class includes the "`booktabs`" package — https://ctan.org/pkg/booktabs — for preparing high-quality tables.

Table captions are placed *above* the table.

Because tables cannot be split across pages, the best placement for them is typically the top of the page nearest their initial cite. To ensure this proper "floating" placement of tables, use the environment **table** to enclose the table's contents and the table caption. The contents of the table itself must go in the **tabular** environment, to be aligned properly in rows and columns, with the desired horizontal and vertical rules. Again, detailed instructions on **tabular** material are found in the *LaTeX User's Guide*.

Immediately following this sentence is the point at which Table 3 is included in the input file; compare the placement of the table here with the table in the printed output of this document.

To set a wider table, which takes up the whole width of the page's live area, use the environment **table*** to enclose the table's contents and the table caption. As with a single-column table, this wide table will "float" to a location deemed more desirable. Immediately following this sentence is the point at which Table 4 is included in the input file; again, it is instructive to compare the placement of the table here with the table in the printed output of this document.

Always use midrule to separate table header rows from data rows, and use it only for this purpose. This enables assistive technologies to recognise table headers and support their users in navigating tables more easily.

## 12 Math Equations

You may want to display math equations in three distinct styles: inline, numbered or non-numbered display. Each of the three are discussed in the next sections.

### 12.1 Inline (In-text) Equations

A formula that appears in the running text is called an inline or in-text formula. It is produced by the **math** environment, which can be invoked with the usual `\begin . . . \end` construction or with the short form `$ . . . $`. You can use any

of the symbols and structures, from $\alpha$ to $\omega$, available in LaTeX [29]; this section will simply show a few examples of in-text equations in context. Notice how this equation: $\lim_{n\to\infty} x = 0$, set here in in-line math style, looks slightly different when set in display style. (See next section).

### 12.2 Display Equations

A numbered display equation—one set off by vertical space from the text and centered horizontally—is produced by the **equation** environment. An unnumbered display equation is produced by the **displaymath** environment.

Again, in either environment, you can use any of the symbols and structures available in LaTeX; this section will just give a couple of examples of display equations in context. First, consider the equation, shown as an inline equation above:

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

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 LaTeX's able handling of numbering.

## 13 Figures

The "`figure`" environment should be used for figures. One or more images can be placed within a figure. If your figure contains third-party material, you must clearly identify it as such, as shown in the example below.

Your figures should contain a caption which describes the figure to the reader.

Figure captions are placed *below* the figure.

Every figure should also have a figure description unless it is purely decorative. These descriptions convey what's in the image to someone who cannot see it. They are also used by search engine crawlers for indexing images, and when images cannot be loaded.

A figure description must be unformatted plain text less than 2000 characters long (including spaces). **Figure descriptions should not repeat the figure caption – their purpose is to capture important information that is not already provided in the caption or the main text of the paper.** For figures that convey important and complex new information, a short text description may not be adequate. More complex alternative descriptions can be placed in an appendix and referenced in a short figure description. For example, provide a data table capturing the information in a bar chart, or a structured list representing a graph. For additional information regarding how best to write figure descriptions and why doing this is so important, please see https://www.acm.org/publications/taps/describing-figures/.

### 13.1 The "Teaser Figure"

A "teaser figure" is an image, or set of images in one figure, that are placed after all author and affiliation information, and before the body of the article, spanning the page. If you wish to have such a figure in your article, place the command immediately before the `\maketitle` command:

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}
\end{teaserfigure}
```

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The use of BibTEX for the preparation and formatting of one's references is strongly recommended. Authors' names should be complete — use full first names ("Donald E. Knuth") not initials ("D. E. Knuth") — and the salient identifying features of a reference should be included: title, year, volume, number, pages, article DOI, etc.

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```
\bibliographystyle{ACM-Reference-Format}
\bibliography{bibfile}
```

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```
\citestyle{acmauthoryear}
```

Some examples. A paginated journal article [2], an enumerated journal article [14], a reference to an entire issue [13], a monograph (whole book) [28], a monograph/whole book in a series (see 2a in spec. document) [21], a divisible-book such as an anthology or compilation [16] followed by the same example, however we only output the series if the volume number is given [17] (so Editor00a's series should NOT be present since it has no vol. no.), a chapter in a divisible book [46], a chapter in a divisible book in a series [15], a multi-volume work as book [27], a couple of articles in a proceedings (of a conference, symposium, workshop for example) (paginated proceedings article) [4, 19], a proceedings article with all possible elements [45], an example of an enumerated proceedings article [18], an informally published work [20], a couple of preprints [7, 11], a doctoral dissertation [12], a master's thesis: [5], an online document / world wide web resource [1, 36, 47], a video game (Case 1) [35] and (Case 2) [34] and [30] and (Case 3) a patent [44], work accepted for publication [41], 'YYYYb'-test for prolific author [42] and [43]. Other cites might contain 'duplicate' DOI and URLs (some SIAM articles) [26]. Boris / Barbara Beeton: multi-volume works as books [23] and [22]. A presentation [38]. An article under review [8]. A couple of citations with DOIs: [25, 26]. Online citations: [47–49]. Artifacts: [37] and [6].

## 15 Acknowledgments

Identification of funding sources and other support, and thanks to individuals and groups that assisted in the research and the preparation of the work should be included in an acknowledgment section, which is placed just before the reference section in your document.

This section has a special environment:

```
\begin{acks}
...
\end{acks}
```

so that the information contained therein can be more easily collected during the article metadata extraction phase, and to ensure consistency in the spelling of the section heading.

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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:

```
\appendix
```

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

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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 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.

**`margintable`:** Place a table in the margin.

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## A Research Methods

### A.1 Part One

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## B Online Resources

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