New Perspectives on Low-Fidelity Prototyping: A Systematic Mapping Study on Tools and Functionalities

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***Abstract. Introduction**: Low-fidelity prototyping is a key approach in User-Centered Design (UCD), enabling quick and cost-effective exploration of interface ideas before implementation. **Objective**: Identify and characterize low-fidelity prototyping tools with respect to their functionalities, limitations, and applicability. **Methodology**: A Systematic Mapping Study (SMS) was conducted. From an initial sample of 1493 publications obtained on Scopus, IEEE Xplore, ACM Digital Library, and ScienceDirect, we selected 37 studies after applying inclusion and exclusion criteria. **Results**: We identified 22 low-fidelity prototyping tools, highlighting Figma, Balsamiq, and PowerPoint as the most frequently cited. Results show limited integration of emerging technologies such as artificial intelligence, reduced functionality in tools exclusively made for low-fidelity prototyping, and scarce incorporation of structured design guidelines, leaving quality assurance primarily as a software professional's responsibility.*
***Keywords** Low-fidelity prototyping, Prototyping tools, User Interface Design*

1. Introduction

User-Centered Design (UCD) is a development approach focused on the needs and limitations of end users [Abras et al. 2004, Gomes Raulino et al. 2024]. It is based on research, interviews, and testing to create intuitive and practical solutions. Its process is iterative, with prototypes being continuously refined based on user feedback, ensuring the final product aligns with real user demands [Chammas et al. 2015]. In this context, prototyping is essential for validating ideas and anticipating problems in interface development, allowing a visual and functional representation of a solution before implementation [McCurdy et al. 2006, Romero et al. 2024]. Prototype fidelity refers to how closely it resembles the final product and can range from low to high [Barbosa et al. 2021]. Low-fidelity prototypes are simpler and ideal for exploring initial concepts, while medium- and high-fidelity prototypes offer greater visual and functional detail, enabling more realistic user testing [Coyette et al. 2007, Li et al. 2021].

Low-fidelity prototyping stands out for its simplicity and efficiency in the early stages of development [Brooks e Lopes 2023]. Common examples include paper sketches, hand-drawn wireframes, or those created with digital tools [Li et al. 2021]. One of its main advantages is the agility in building Minimum Viable Products (MVPs), allowing rapid structuring and validation of ideas [Alonso et al. 2021]. In this sense, interface prototyping tools have become increasingly common in the user-centered design process. Tools like Figma [1], Balsamiq [2], and Adobe XD [3] enable the creation of prototypes, offering interactive and collaborative features that facilitate usability testing and team communication [Oliveira e Monteiro 2024, Sangiorgi et al. 2014]. The growing adoption of these tools reflects an industry-wide movement toward the digitization of design stages [Carter e Hundhausen 2010].

The Human-Computer Interaction (HCI) literature addresses the theme of interface prototyping from various perspectives, such as the work of Nissinen et al. [Nissinen 2015], which reviews UX concepts and fidelity levels, and the systematic review by [Freitas et al. 2020], which focuses on solutions for Augmented Reality applications. Other authors, such as [Li et al. 2021], analyze the accessibility of high-fidelity tools, while [Gudoniene et al. 2023] explores the use of artificial intelligence in the automated generation of wireframes. Despite the existence of several tools aimed at interface prototyping and the recent interest in the topic [Li et al. 2021], there is still a gap in the literature regarding a systematic and consolidated view of new digital solutions specifically for low-fidelity prototyping, as using high-fidelity prototyping tools for this purpose may require more technical knowledge than necessary. This gap hinders informed decision-making by software professionals, highlighting the need for a critical, updated, and organized analysis of the topic.

In this context, this study aimed to identify and characterize the tools used for low-fidelity prototyping, including their features, limitations, and application areas. To achieve this, we conducted a Systematic Mapping Study (SMS), observing the structure proposed by Kitchenham and Charters [Kitchenham e Charters 2007], with the following main research question: "What are the tools used for low-fidelity interface prototyping?" To answer this research question, we analyzed 1,493 initial studies from four scientific databases (Scopus, IEEE Xplore, ACM Digital Library, and ScienceDirect), of which 37 were selected after applying the established criteria. We identified 22 tools for low-fidelity prototyping, with Figma, Balsamiq, and PowerPoint being the most frequently cited in the scientific literature.

As a result, we found that tools designed exclusively for low-fidelity prototyping generally offer fewer features. Moreover, existing tools show limited integration of emerging technologies, such as artificial intelligence. We also observed that only 22.73% of these tools incorporate specific methods, heuristics, or guidelines for designing and evaluating prototypes, placing the responsibility for interface quality solely on professionals. Finally, we found a prevalence of general-purpose tools adapted for prototyping. As a practical contribution, our results can support decision-making for software teams that wish to prototype in low fidelity, highlighting new tools specific to this task and their features. For the scientific community, our study opens possibilities for research that seeks to intersect the low-fidelity prototyping technique with other topics, such as automated creation and evaluation using artificial intelligence, incorporation of evaluation techniques in digital tools, and development of new plugins for existing tools.

[1] https://www.figma.com
[2] https://balsamiq.com
[3] https://helpx.adobe.com/br/xd/get-started.html

2. Related Work

[Nissinen 2015] presents a literature review on UX prototyping, highlighting the benefits of low-fidelity prototyping in the early stages of design to explore alternatives, obtain quick feedback, and reduce costs. The study classifies prototypes into low, high, and mixed fidelity, and discusses how each type serves different goals and stages of the user-centered design process. Tools such as Balsamiq [Balsamiq Studios, LLC 2025], Axure RP [Solutions 2025], and SILK are also analyzed, emphasizing their usability, collaboration support, and interaction realism characteristics. A key point raised is the challenge of prototyping interactive behaviors, which often require iteration and specific technical skills. Although the study provides a comprehensive conceptual view on the role of prototyping for communication, validation, and idea iteration, it does not perform a systematic mapping nor delve into the functional characterization of the tools used, which limits its practical application in specific contexts.

[Freitas et al. 2020] presents a systematic review of tools, frameworks, and software for rapid prototyping of Augmented Reality (AR) applications, focusing on low-fidelity prototypes. The study analyzed 39 resources, including academic and gray literature, and identified at least 30 artifacts, ranging from traditional methods such as paper, storyboards, and the Wizard of Oz technique to digital tools like Unity, Vuforia, and Tilt Brush. The authors highlight the specific challenges of AR prototyping, such as camera simulation, 3D content creation, and integration with tracking technologies. Additionally, they point out the lack of accessible solutions for non-programmers and reinforce the importance of hybrid methods and adaptations of conventional techniques to address the particularities of three-dimensional and interactive applications. The work also shows that simple approaches like videos, presentations, and physical prototypes are still widely used despite technological advances due to their agility and low cost, especially in early design phases.

[Li et al. 2021] conducts a systematic analysis of the accessibility of popular high-fidelity prototyping tools for users with visual impairments. The research evaluates four widely used tools in combination with screen readers, examining compliance with accessibility guidelines and the feasibility of essential design workflows. The results reveal that only 45.9% of the evaluated interface elements were fully accessible, with recurrent issues such as missing alternative text, improper focus order, and canvas elements inaccessible via keyboard. Creating and manipulating elements on the canvas proved especially challenging, compromising the autonomy of blind or low-vision designers. Beyond highlighting technical barriers, the article emphasizes how the lack of accessibility in tools directly impacts the inclusion of these professionals and, indirectly, the accessibility and quality of final products. Thus, the study contributes a functional analysis of the tools and recommendations to make them more inclusive, serving as a source for mapping functionalities and limitations in accessible design contexts.

[Gudoniene et al. 2023] proposes and evaluates, in an educational setting, the use of the Uizard tool for generating wireframes from hand-drawn sketches. Through case studies with master's students in engineering, the study compares two scenarios: automatic and manual creation of low-fidelity prototypes. The results reveal differences in execution time and ease of use, highlighting the efficiency provided by AI. Furthermore, the study emphasizes the potential of AI-based tools to make education more personalized, inclusive, and efficient while acknowledging the technical challenges and limitations of current technologies. The authors also stress the importance of further research, especially regarding automatic code generation and the creation of high-fidelity prototypes.

The reviewed studies address relevant aspects of usability, UX evaluation, and technologies applied to prototyping. However, we did not find secondary studies that comprehensively mapped tools aimed explicitly at low-fidelity prototyping, considering their functionalities, limitations, and integration with emerging technologies. Therefore, our Systematic Mapping Study aimed to fill this gap by providing a structured and up-to-date overview of the state of the art in low-fidelity prototyping tools.

3. Systematic Mapping Study

The Systematic Mapping Study (SMS) is a broad review approach that aims to identify and categorize the available evidence on a given topic. Through the analysis of primary studies, the SMS provides an overview of the existing research landscape, enabling an understanding of the volume, nature, and gaps in knowledge within a specific area [Kitchenham e Charters 2007].

Following the guidelines recommended by Kitchenham and Charters [Kitchenham e Charters 2007], we structured the research protocol into three phases: planning, execution, and reporting. In the planning phase, we developed the research protocol, including the research questions, data sources to be consulted, search strategy, and inclusion and exclusion criteria. During the execution phase, we searched the selected databases, extracted relevant information from the included studies, and performed data analysis. Finally, in the reporting phase, we present and discuss the results.

3.1. Planning

3.1.1. Objective

The objective of the SMS was based on the GQM (Goal-Question-Metric) paradigm [Basili e Rombach 1988] and is described in Table 1.

Table 1. SMS objective according to the GQM paradigm

Analyze	scientific publications
With the purpose of	identifying
With respect to	the tools that are used for low-fidelity prototyping
From the point of view of	HCI researchers and software professionals
In the context of	primary sources available in SCOPUS, ACM, IEEExplore, Science Direct

3.1.2. Research Questions

The main research question (RQ) is: "What are the tools used for low-fidelity interface prototyping?". Here, “tools used” refers specifically to those reported in academic studies and experiments. In addition to this central question, we defined complementary sub-questions (SQs), presented and explained in Table 2.

Table 2. Research sub-questions

Research sub-questions	**Possible answers and rationale**
SQ1. What is the type of platform on which the tool was developed?	Identifying the platform helps understand the tool's applicability across different environments. The tool may have been developed for one or more of the following platforms: a) Mobile; b) Desktop; c) Web.
SQ2. Is the tool exclusive for low-fidelity prototyping?	Identifying exclusivity to low-fidelity helps clarify the tool's intended use, complexity, and suitability for early design phases. The use of the tool may or may not be restricted to the fidelity level of the prototypes: a) Yes, the tool is exclusively aimed at low-fidelity prototyping; b) No, the tool can be used for prototyping at different fidelity levels (low, medium, or high).
SQ3. What functionalities and features are offered by low-fidelity prototyping tools?	Listing functionalities helps assess the level of support the tool provides during the prototyping process. The tool may offer one or more of the following features, among others not listed below: a) Library of ready-made components; b) Drag and drop functionality; c) Creation of interactive prototypes; d) Generation of wireflows (screen flows).
SQ4. Do low-fidelity prototyping tools have any associated cost?	Cost impacts tool accessibility, especially in academic or small-team contexts. The tools may use different models of access and charging: a) Yes, the tool has paid versions (with premium features); b) No, the tool is completely free; c) The tool uses a freemium model (free version with limitations and paid plans).
SQ5. What are the types of platforms for which software can be prototyped using the tool?	Indicates whether the tool can support design needs for different software environments. The tool allows prototyping systems aimed at: a) Mobile applications; b) Desktop applications; c) Web applications.

Research sub-questions	Possible answers and rationale
SQ6. Are there mentions of positive/negative aspects and feedback about the use of the tool?	Feedback provides insights into user experience and practical limitations or strengths. The analyzed studies may or may not present qualitative perceptions about the tool: a) Yes, the study presents comments on positive, negative aspects and/or user feedback; b) No, the study does not present this type of information.
SQ7. Does the tool incorporate methods, heuristics, or specific guidelines for the design and/or evaluation of prototypes?	Incorporating guidelines can improve consistency and quality in the design or evaluation process. The tool may adopt systematic guidelines in the design and/or evaluation process of prototypes: a) Yes, the tool adopts specific design or evaluation methods, heuristics, or guidelines (e.g., Nielsen's heuristics); b) No, the tool does not explicitly mention or incorporate such approaches.

3.1.3. Data Sources

We conducted the research using advanced search mechanisms in digital libraries widely recognized in the fields of Computer Science and HCI. These include: Scopus[4], IEEE Xplore[5], ACM Digital Library[6], and ScienceDirect[7].

3.1.4. Search String

We developed the search string using two main groups of keywords. The first group includes terms related to low-fidelity prototyping, while the second comprises words associated with tools and their synonyms. This approach aims to ensure that the highest possible number of relevant studies are retrieved. Table 3 presents the terms used in the search string.

Table 3. Terms used in the search string

Prototyping	(low-fidelity prototyping OR low-fidelity interface OR low-fidelity design)	AND
Tool	(tool OR software OR application OR platform OR system OR program)	

[4]https://www.scopus.com/search/form.uri?display=basic
[5]https://ieeexplore.ieee.org/Xplore/home.jsp
[6]https://dl.acm.org/
[7]https://www.sciencedirect.com/

3.1.5. Inclusion and Exclusion Criteria

To select the studies, the following inclusion criteria (IC) were defined:

- IC1 – Publications that present or use tools for low-fidelity prototyping;
- IC2 – Publications that describe case studies or practical examples of applying low-fidelity prototyping tools;
- IC3 – Publications that compare different low-fidelity prototyping tools in terms of functionality, efficiency, or user satisfaction.

Likewise, exclusion criteria (EC) were defined to eliminate studies that did not meet the established requirements:

- EC1 – Publications that do not meet the inclusion criteria were not selected;
- EC2 – Publications without accessible content for reading and data analysis (especially in cases where studies are paid or unavailable through search engines) were not selected;
- EC3 – Publications written in languages other than English or Portuguese were not selected;
- EC4 – Publications considered as gray literature, such as technical reports and works in progress, were not selected;
- EC5 – Duplicate publications already included through another search engine were not selected.

3.2. Execution

3.2.1. Study Selection

The SMS started in June 2024. The metadata of the extracted studies was exported from their respective search engines and underwent a selection process, carried out by two researchers involved in the study with the aid of an exclusive *[anonymous]* tool developed specifically for this work. The process comprised the following steps:

- Step 1: The title, abstract, keywords, and authors' names of the studies were reviewed to classify the publications according to predefined inclusion and exclusion criteria. The researchers individually assessed each study, assigning the publication to one of the criteria and justifying their choices. In case of disagreement in classification, a discussion was held to reach a consensus on the final decision. In this step, the researchers achieved 95.45% agreement and a Kappa value of 0.7609, indicating moderate agreement [McHugh 2012];
- Step 2: The studies selected in the previous step underwent full-text reading. During this phase, the same inclusion (IC) and exclusion criteria (EC) were applied, maintaining the same assessment approach by the researchers. In this step, the researchers reached 96.67% agreement, with a Kappa value of 0.8387, indicating strong agreement [McHugh 2012].

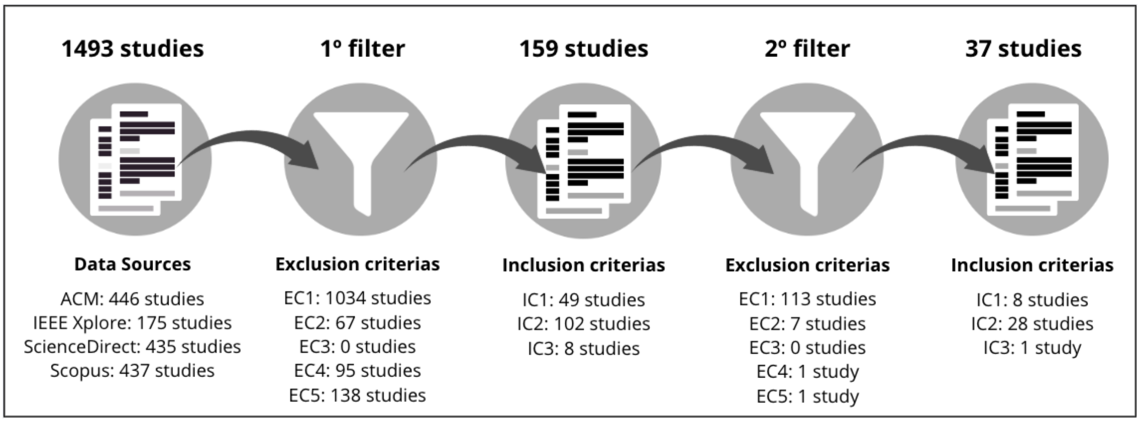

Figure 1. Quantitative summary of the study selection process

3.2.2. Data Extraction and Analysis

The metadata of the selected studies was organized in tabular format, enabling more efficient and structured data extraction. We analyzed each study to identify answers to the main research question and the related SQs. In addition to reading the studies, further investigation was required whenever a tool was mentioned. This investigation included searching for additional information from external sources, such as the tools' official documentation. Thus, the analysis was not limited to the content presented in the studies but included an additional complementary research step to ensure the comprehensiveness and quality of the answers.

3.3. Reporting

3.3.1. Selected Studies

As mentioned, 37 studies were selected for data extraction and are presented in Table 4, along with their respective titles and authors.

Table 4. Studies selected in the SMS

ID	Title
S1	Low-fidelity prototyping of gesture-based applications [Hosseini-Khayat et al. 2011]
S2	WOZ pro: a pen-based low fidelity prototyping environment to support wizard of oz studies [Hundhausen et al. 2007]
S3	Prototipação de software e design participativo: uma experiência do atlântico [Rosemberg et al. 2008]
S4	Visualization-Enhanced Aggregated Search Interfaces [Momeni 2024]
S5	UnlockMe: Social Interactions when Co-located in Online Activities [Viswanathan e Legras 2021]
S6	A mixed-fidelity prototyping tool for mobile devices [de Sá et al. 2008]
S7	Increasing interactivity of paper prototyping with smart pen [Ha et al. 2014]
S8	A visual language for sketching large and complex interactive designs [Lin et al. 2002]

ID	Title
S9	GUIfetch: supporting app design and development through GUI search [Behrang et al. 2018]
S10	Developing the family support tool: An interactive, web-based tool to help families navigate the complexities of surrogate decision making in ICUs [Suen et al. 2020]
S11	Developing a mobile application to better inform patients and enable effective consultation in implant dentistry [Canbazoglu et al. 2016]
S12	Designing a tablet-based prematurity education app for parents hospitalized for preterm birth [Rau et al. 2020]
S13	Requirements engineering for e-Government services: A citizen-centric approach and case study [van Velsen et al. 2009]
S14	Converting and expanding mobile support tools for tuberculosis treatment support: Design recommendations from domain and design experts [Iribarren et al. 2020]
S15	A user-centered model for designing consumer mobile health (mHealth) applications (apps) [Schnall et al. 2016]
S16	The design and experimental evaluation of a tool to support the construction and wizard-of-oz testing of low fidelity prototypes [Hundhausen et al. 2008]
S17	Activity-Centered Design of Web User Experience: A One-Stop Application for Design Sprints [Diandraputri e Niwanputri 2021]
S18	Preliminary Work on Design Thinking: Addressing Challenges using Low-fidelity Prototyping with Rural Teenagers [Ghazali et al. 2018]
S19	Designing a Mindful Computerized Therapy Module to Reduce Depression [Noor et al. 2023]
S20	E-tinerary: A decision support approach for tourist trip planning [Borges Lopes et al. 2020]
S21	Designing Software for Genomics Medicine Service Leaders to Engage Stakeholders [Coffen-Burke et al. 2023]
S22	Spoonful: Mobile Application for Reducing Household Food Waste using Fogg Behavior Model (FBM) [Akmal e Niwanputri 2021]
S23	The Design of a Mobile App for Promotion of Physical Activity and Self-Management in Prostate Cancer Survivors: Personas, Feature Ideation and Low-Fidelity Prototyping [Monteiro-Guerra et al. 2017]
S24	Interaction Design of Indonesian Junior High School Academic Information System using User-Centered Design [Amara Hanieka e Arifiansyah 2023]
S25	Designing and Developing a Mobile Application for Monitoring & Visualizing Blood Pressure Data [Sinaei Hamed et al. 2023]
S26	A User-Centered Approach to Design a Financial Asset Investment Mobile Application for Building Investing Eagerness [Vianiryzki e Niwanputri 2021]
S27	Designing Interaction of Institut Teknologi Bandung Mental Health Services [Nugroho et al. 2022]
S28	Respinos Health: A Mobile Health App Designed Using User-Centered Design Method to Use with Respinos [Rahman et al. 2023]
S29	Heuristic And Think Aloud Method To Evaluate The Low Fidelity Prototype Of Game-Based Language Learning Application [Ishaq et al. 2021]

ID	Title
S30	SereneMind: Design and Evaluation of a Persuasive Mobile App for Managing Stress Among Adults [Alhasani et al. 2023]
S31	Rationalizing Dark Patterns: Examining the Process of Designing Privacy UX Through Speculative Enactments [Nelissen e Funk 2022]
S32	The Scenarios of Artificial Intelligence and Wireframes Implementation in Engineering Education [Gudoniene et al. 2023]
S33	The longevity of general purpose Wizard-of-Oz tools [Pettersson e Wik 2015]
S34	UISKEI: A sketch-based prototyping tool for defining and evaluating user interface behavior [Segura et al. 2012]
S35	User interface design by sketching: A complexity analysis of widget representations [Kieffer et al. 2010]
S36	Building interactive prototypes of mobile user interfaces with a digital pen [Holzmann e Vogler 2012]
S37	PROTEUS: Artefact-driven constructionist assessment within Tablet PC-based low-fidelity prototyping [Mohamedally et al. 2006]

3.3.2. Publication Years

Regarding the publication years of the studies, as shown in Figure 2, there is an increase in the number of publications over the years, suggesting growing interest in the investigated topic. The years 2020, 2021, and 2023 stand out, with the highest numbers of publications. We highlight that the data for 2024 could not be thoroughly analyzed, as we conducted data collection in June 2024 and therefore does not cover the entire year.

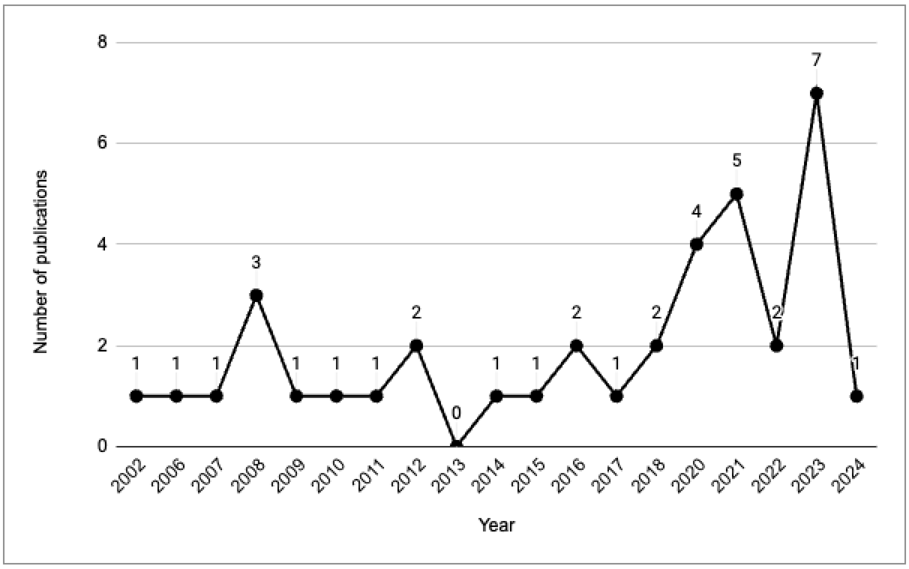

Figure 2. Years of publication of the studies

4. Results

The analysis spreadsheet that supported the results presented in this article can be found in the following link[8]. In response to the main RQ (What are the tools used for low-fidelity interface prototyping?), 22 tools were identified, as shown in Table 5. The most frequently used tools across the studies are Figma (N = 7), Balsamiq (N = 5), and PowerPoint (N = 4). The remaining results related to the SQs and detailed information about these tools are discussed in the following subsections.

Table 5. Tools identified in studies

Name	Studies mentioned	Total
Figma	S4, S17, S21, S22, S24, S27, S28	7
Balsamiq	S11, S14, S20, S30, S32	5
PowerPoint	S12, S13, S15, S19	4
Adobe XD	S26, S31	2
Pencil project	S9, S18	2
Sketch	S5, S10	2
Woz pro	S2, S16	2
N/A [Kieffer et al. 2010]	S35	1
N/A [Holzmann e Vogler 2012]	S36	1
Denim	S8	1
N/A [de Sá et al. 2008]	S6	1
Microsoft Visio	S3	1
NinjaMock	S23	1
Ozlab	S33	1
ActiveStory Touch	S1	1
N/A [Ha et al. 2014]	S7	1
Proteus	S37	1
Adobe Illustrator	S29	1
UISKEI	S34	1
Uizard	S32	1
Adobe Photoshop	S29	1
Microsoft OneNote	S25	1

4.1. SQ1: Platforms on which low-fidelity prototyping tools were developed

Regarding the platforms on which low-fidelity prototyping tools were developed, we observed that desktop is the most common, supported by approximately 81.82% of the tools analyzed (N = 18). One example is the tool ActiveStory Touch, developed in study S1, which uses the C# programming language [Microsoft Corporation 2024] and was implemented as a desktop application.

The web platform ranks second, with support in approximately 45.45% of the tools (N = 10). The mobile platform is the least represented, present in only 31.82% of the tools (N = 7). An example is the tool developed in study S36, specifically designed for Android devices, which, according to the authors, leverages the popularity of the

[8]https://figshare.com/s/890c9963e193b87aff5a

operating system and the ease of integration with digital pens via Bluetooth. The tool N/A [Ha et al. 2014] (S7), in turn, supports both desktop and mobile platforms, enhancing its versatility.

Another relevant finding is that 31.82% of the tools (N = 7) support two or more platforms. Figma, Balsamiq, and PowerPoint are the three most frequently mentioned tools in the analyzed studies. These tools are available in both desktop and web versions. It is also worth noting that three tools (Adobe Photoshop, PowerPoint, and Microsoft OneNote) support all three platforms: desktop, web, and mobile.

4.2. SQ2: Tools exclusive to low-fidelity interface prototyping

We analyzed the fidelity levels of prototypes developed using the tools. We found that all the tools investigated support the creation of low-fidelity prototypes. However, approximately 45.45% (N = 10) are used exclusively for this type of prototyping, meaning they do not extend to high-fidelity prototyping. Among these exclusive tools, Balsamiq is the second most frequently used tool in the reviewed studies, widely adopted in user-centered design processes.

In study S11, Balsamiq was used to create wireframes for a communication app between dentists and patients, with strong user involvement in the ideation and interface validation phases. Another example is study S30, which described its use in the development of a stress management app. The tool was applied to generate visual mockups of the main features, which real users later evaluated.

Other tools classified as exclusive to low-fidelity prototyping, such as N/A [de Sá et al. 2008] (S6), N/A [Holzmann e Vogler 2012] (S36), N/A [Ha et al. 2014] (S7), ActiveStory Touch, Denim, NinjaMock, Proteus, and Woz Pro, appear sporadically in the scientific literature, indicating more limited adoption. On the other hand, tools widely used in industry, such as Figma, PowerPoint, Adobe XD, Sketch, Microsoft Visio, Adobe Illustrator, Adobe Photoshop, and Microsoft OneNote, although they also support low-fidelity prototyping, are not exclusive to that purpose.

Although not originally intended as an interface prototyping tool, PowerPoint is among the most frequently mentioned tools. Study S12 used PowerPoint to prototype an educational app for parents at risk of premature birth, emphasizing user and expert participation. Study S15 used the tool in participatory sessions and heuristic evaluations while creating an mHealth app.

Figma, identified as the most frequently used tool in the analyzed studies, has been used to create both low- and high-fidelity prototypes. For instance, in study S20, it was used to develop prototypes aimed at collecting stakeholder feedback in genomic medicine services, while in study S27, it was used to improve a mental health application, with a focus on accessible and consistent design.

4.3. SQ3: Features of low-fidelity prototyping tools

The features of low-fidelity prototyping tools were organized into four main groups: collaboration, prototyping, components, and artificial intelligence (AI), as indicated in Table 6.

Among the categories analyzed, the functionalities related to prototyping were the most recurrent. Notably, the creation of wireframes (FN7) and wireflows (FN8)

Table 6. Classification of the tool features

Classification	ID	Feature
Collaboration	FN1	Creation of separate projects
	FN2	Granular permissioning among users
	FN3	Multiple team members can work simultaneously on the same file, with updates visible in real-time
	FN4	Allows users to add comments directly on the design
	FN5	Ability to view and restore previous versions of the design
	FN6	Files can be stored in the cloud, accessible from any device with an internet connection
Prototyping	FN7	Wireframe creation
	FN8	Creation of wireflows
	FN9	Auto Layout tool, which adjusts the design as content changes, ideal for creating responsive interfaces
	FN10	Ability to add interactions between screens and components
	FN11	Creation of grid systems for alignment.
	FN12	Allows viewing designs directly in fullscreen mode, simulating a real user interface experience
	FN13	Keyboard shortcuts (zoom, move, create, and delete components)
Components	FN14	Allows editing the component's text
	FN15	Allows you to change borders, spacing, and margins
	FN16	Allows dragging components between screens (drag and drop)
	FN17	Allows resizing components
	FN18	Allows creating reusable components and updating them globally
	FN19	Allows creating different states of the same component (e.g., active button, disabled, with hover)
	FN20	Offers a gallery of pre-made components for different purposes, such as app, website, and dashboard design
AI	FN21	Prototype creation via AI
	FN22	Suggestions for design improvements and feedback through AI
	FN23	Prototype generation from a sketch (paper prototyping) via AI

stood out, being present in all tools that directly address interface construction. The authors of study S8 indicate that the creation of wireframes is described as the main functionality of the Denim tool, allowing designers to sketch on paper and convert those sketches into interactive digital prototypes. Similarly, the authors of study S7 highlight this functionality as part of the workflow of the tool N/A [Ha et al. 2014] (S7), aimed at rapid prototyping of website pages.

The functionality for creating wireflows (FN8) also proved relevant, as it visually represented navigation between screens. In studies S7 and S8, designers used arrows and connections between wireframes to define transitions and interactions, resulting in prototypes that simulate complete navigation experiences.

In the collaboration group, functionalities FN1 and FN4 stood out, appearing in 90.91% of the analyzed tools (N = 20). The latter functionality is evidenced, for example, in study S11, where notes and comments are added directly onto sketches and wireframes in Balsamiq, facilitating the iteration and communication process among project participants (such as designers and healthcare professionals).

Functionalities aimed at manipulating components were also widely identified. FN14, FN15, and FN17 were found in 90.91% of the tools (N = 20). These capabilities emphasize the importance of offering visual editing freedom and refinement during the design phase, enabling dynamic adjustments to the interface.

On the other hand, functionalities related to artificial intelligence are still in the early stages of adoption. Prototype generation from physical sketches (FN23) was identified in only 9.09% of the tools (N = 2). An example is the tool Uizard, used in study S32, which employs AI to convert hand-drawn wireframes into digital prototypes through the Uizard tool. This tool also incorporates automated improvement suggestions (FN22) and AI-based prototype generation (FN21), functionalities that, although promising, still show modest adoption rates — 27.27% (N = 6) and 31.81% (N = 7), respectively.

Overall, there is a significant variation in the coverage of features across the tools. Sketch and Uizard stand out for offering all of the mapped features (N = 23), followed by Figma (N = 22) and the tools Adobe Photoshop, Adobe XD, and NinjaMock (N = 19 each). In contrast, tools like N/A [Ha et al. 2014] (S7) offer only 17.39% of the features (N = 4), while Denim — despite its specific focus — includes 26.09% (N = 6). The tool developed by [de Sá et al. 2008] (S6) and ActiveStory Touch offer 30.43% (N = 7), which highlights a more limited approach in terms of design functionalities.

4.4. SQ4: Costs of low-fidelity prototyping tools

Regarding the cost of the identified tools, there is a diversity in access models. Approximately 45.45% of the tools (N = 10) are completely free, allowing unrestricted use without needing payment. However, many of these tools are not among the most mentioned in the studies analyzed. About 27.27% of the tools (N = 6) follow a free trial model, usually ranging from 7 to 30 days, requiring payment after this period. Examples include Adobe Illustrator, Adobe Photoshop, and Balsamiq, which offer an initial free usage period but restrict access afterward.

Furthermore, 18.18% of the tools (N = 4) follow a *freemium* model, meaning they offer a free plan with limited features and paid plans with more advanced resources. This model is the case with Figma, PowerPoint, and Uizard, among the most frequently cited tools, suggesting that a free version, even if limited, can contribute to their initial adoption. Another 13.64% of the tools (N = 3) are only accessible through payment, without offering a free version or trial period, such as Microsoft Visio, NinjaMock, and Microsoft OneNote.

Finally, the Ozlab tool, presented in study S33, has restricted access to the university where it was developed and is intended for internal use in the academic context. Used for over 15 years, this tool stands out for its continuity and prolonged application in teaching and research activities, despite not being widely available to the external public.

4.5. SQ5: Platforms on which software can be prototyped using the tools

Out of the 22 tools analyzed, 86.36% (N = 19) support prototyping for the three main platforms (mobile, web, and desktop) while only three tools (13.64%), identified as N/A [de Sá et al. 2008] (S6), N/A [Holzmann e Vogler 2012] (S36), and N/A [Ha et al. 2014] (S7), are limited exclusively to mobile device prototyping.

Although the tools can build prototypes for the desktop platform, we highlight that none of the studies analyzed used this platform as the target for prototyping. Examples from the studies illustrate this trend. In S10, using the Sketch tool, a multi-platform web application was developed that is available on personal computers and Android and Apple tablets. The application was designed to assist families in decision-making in ICU settings, emphasizing the potential of web support in critical health contexts. In S17, Figma was used to create a web-oriented desktop application to assist users through all stages of a design sprint.

The mobile platform, on the other hand, stands out in several applications. In S18, for example, teenagers used Balsamiq to prototype mobile apps that addressed everyday challenges. The authors of S23 used the NinjaMock tool to develop an app aimed at smartphones that promotes physical activity and self-management in prostate cancer survivors. Using the Microsoft OneNote tool, in S25, the prototyping of an Android app for visualizing and monitoring blood pressure data was carried out.

4.6. SQ6: Positive and negative points and feedback on the tools

The tools analyzed demonstrated strengths, particularly in ease of use, intuitive interfaces, and various available features. The tool N/A [de Sá et al. 2008], developed in study S6 and used by designers in two distinct experiments, was well-received by the designers in the case studies, standing out for its good balance between usability and feature richness.

Other tools also presented relevant positive aspects. Balsamiq, for instance, stood out for its speed in creating wireframes and its simplicity of use, as noted in studies S11 and S32. However, in study S32, important limitations were also identified, such as the lack of collaborative features and the absence of more advanced integration capabilities with other platforms. In study S37, the Proteus tool was evaluated through a comparative study involving 40 graduate students, who assessed its use compared to traditional paper prototyping. About 82% of the participants considered the tool to be similar to or better than the paper method, reinforcing its potential to replace analog approaches. The authors of S32 indicated that Uizard can quickly convert manual sketches into digital prototypes, with excellent real-time collaboration, version control support, and the ability to import wireframes developed in Balsamiq.

However, the tools also received significant criticism on various points. N/A [Ha et al. 2014], in study S7, was negatively evaluated due to the need to repeatedly draw similar elements, making the process monotonous and frustrating for users. Additionally, the lack of system feedback during the conversion of sketches hindered the user experience, while interaction lines made the prototypes visually confusing. The UISKEI tool, in study S34, faced the challenge of a steep initial learning curve and difficulties with pen-based interaction. However, its ease of use after the initial phase and good dynamic visualization of actions and events were highlighted. Finally, in study S16, Woz Pro received criticism about its slowness and complexity when creating transitions between states and components, which hindered the agility in the prototyping process [Hundhausen et al. 2008].

4.7. SQ7: Methods, heuristics, or guidelines for the design and/or evaluation of prototypes incorporated in the tools

Only 5 of the 22 tools analyzed incorporate specific methods, heuristics, or guidelines for designing and evaluating prototypes, with only 2 of them being exclusive to low-fidelity prototyping. Tools such as the one developed by [de Sá et al. 2008] stand out, as it implements User-Centered Design (UCD), incorporating usability guidelines in medium-fidelity prototypes and supporting evaluation techniques such as the Wizard of Oz method [Maulsby et al. 1993] and data collection methods like the Experience Sampling Method [Consolvo e Walker 2003]. Other tools, such as Adobe XD and Figma, offer integration with design systems and plugins that allow for the application of guidelines, such as those proposed by Material Design [Google 2021] and the Apple Human Interface Guidelines [Inc. 2025]. Similarly, Sketch provides plugins and libraries that facilitate the application of design guidelines, even without formally integrating structured methods. The Woz Pro tool demonstrates a strong orientation toward user-centered design by employing low-fidelity prototyping techniques and the Wizard of Oz method [Maulsby et al. 1993] for evaluation, reinforcing the importance of iterative and participatory approaches.

5. Discussions

The results of SQ1 indicate that the predominant platform among the tools analyzed is desktop. The second most common platform is web, followed by mobile. Only three tools (Adobe Photoshop, PowerPoint, and Microsoft OneNote) provide simultaneous support for all three platforms (desktop, web, and mobile). The limited presence of mobile-focused tools may be attributed to challenges such as adapting to multiple screen resolutions, technical limitations of devices, and the complexity of designing interfaces in reduced spaces. Additionally, mobile development is more recent and, therefore, less consolidated than desktop and web platforms.

The results of SQ2 highlight that Balsamiq stands out as the most used tool exclusively dedicated to low-fidelity interface prototyping. However, tools like PowerPoint, Adobe Illustrator, Adobe Photoshop, Adobe XD, Microsoft Visio, Sketch, and Microsoft OneNote are not explicitly designed for this task. This pattern suggests that professionals in the field often resort to general-purpose tools due to familiarity, integration with their existing workflows, or the limited availability of specialized alternatives. The findings related to SQ2 underscore the lack of tools specifically dedicated to low-fidelity prototyping. This limitation may introduce additional challenges in the process, making the rapid and efficient creation of prototypes for MVP validation a considerable challenge.

Regarding SQ3, we observed that tools dedicated to low-fidelity prototyping generally offer a reduced set of features, especially when considering advanced characteristics such as those related to AI. Although it is expected that low-fidelity tools do not have the same level of complexity as high-fidelity tools, such as detailed visual customization features, all the functionalities analyzed are technically feasible to be incorporated and could contribute to optimizing the initial prototyping process. The absence of these resources indicates a technological and functional limitation in low-fidelity tools, and this gap may explain, in part, the results observed in SQ2, where professionals end up resorting to more comprehensive general-purpose tools, even though they are not explicitly designed for this stage.

Regarding the costs of the tools (SQ4), the results show that paid or hybrid model tools are predominant among professionals. This preference suggests that advanced tools and specialized support are highly valued. Although there are free tools, they were rarely mentioned in the analyzed studies, possibly due to deficiencies in their capabilities or features. However, it is important to highlight that cost can be a barrier, especially for freelancers, independent researchers, small businesses, or individuals at the start of their careers, who often lack sufficient resources to afford commercial tools.

The results of SQ5 demonstrate that most of the tools analyzed enable prototyping for all three major platforms (Mobile, Web, and Desktop). Only a small proportion of them limit support exclusively to prototyping for the Mobile platform. This context reflects the tools' concern with meeting multiple market needs, offering flexibility to users, and allowing different types of applications and systems to be considered in low-fidelity prototyping.

Feedback on the positive and negative aspects of the evaluated tools (SQ6) indicates that users primarily value ease of use, user-friendly and intuitive interfaces, collaborative features, and integration with other tools. On the other hand, users suggested improvements related to performance, clearer error messages, and enhancements in collaboration functionalities, which present an opportunity to improve these tools in the future.

The results of SQ7 show that only 5 of the 22 tools analyzed incorporate methods, heuristics, or specific guidelines related to the design process and the evaluation of prototypes. Of these five, only two are exclusive to low-fidelity prototyping, and none offer support for adding plugins. This feature would allow the developer community to extend their functionalities by incorporating evaluation methods. This limitation represents a challenge, as it places a greater responsibility on professionals for the quality of prototypes, leading to more personal and potentially subjective approaches, which could result in less intuitive and effective interfaces. As highlighted by [Saad et al. 2021, Guerino et al. 2024], software startups often operate with scarce resources and frequently lack specialized UX professionals.

The results demonstrate that, despite the variety of tools available for low-fidelity prototyping, significant challenges remain regarding the absence of specialized solutions, technological and functional limitations, the need for improvements in usability and collaboration, the predominance of cost-associated tools, and the lack of structured support for heuristics and specific methods.

6. Threats to Validity

As with any SMS, there is a risk of bias in the researchers' interpretation. To mitigate this, we adopted a peer evaluation process in two stages. In Stage 1, the researchers read each study's title, abstract, keywords, and authors, classifying them according to inclusion or exclusion criteria. Each decision was justified, and disagreements were resolved through discussion until consensus was reached. In Stage 2, the selected studies underwent a full reading, applying the same criteria and approach. Exclusions required clear justifications, and disagreements were again discussed. This process aimed to ensure greater rigor and reliability in the study selection.

Another potential threat to validity is related to the construction of the search string. Although we developed the string with two main groups of keywords (one related to prototyping and the other to tools and their synonyms), there is still a risk that relevant studies may not have been retrieved because they did not use precisely the chosen terms. For example, tools such as MockFlow [9], Wireframe.cc [10], Mockplus [11], and Flinto [12] were not found in the retrieved studies. However, despite the possibility of omitting some works, the search resulted in a relevant number of studies and was adequate for the analysis.

Finally, it is important to acknowledge the absence of a minimum quality threshold or qualitative assessment criterion in the selection process. All studies that met the inclusion criteria were accepted, regardless of their methodological rigor or depth of analysis. This choice aimed to ensure a broad overview of the topic but may have allowed the inclusion of low-quality or superficial studies. Therefore, the lack of a quality filter can represent a threat to validity, as it potentially reduces the reliability and robustness of the overall findings.

7. Conclusion and Future Work

This paper presented the results of a systematic mapping study on tools used for low-fidelity interface prototyping, identifying 22 distinct tools employed for this purpose. From this analysis, several gaps in the current landscape of low-fidelity prototyping tools were highlighted:

- Tools focused exclusively on low-fidelity prototyping typically offer limited features.
- Existing tools show limited integration of emerging technologies, such as AI.
- Only 5 of the 22 tools incorporate specific methods, heuristics, or guidelines for designing and evaluating prototypes, with only 2 of them being exclusive to low-fidelity prototyping, placing the responsibility for ensuring the quality of interfaces entirely on professionals.
- There is a prevalence of general-purpose tools adapted for prototyping.
- Most analyzed tools are paid or operate on a hybrid model, which may limit access for professionals and organizations with limited resources.

Based on the identified gaps, future work proposes the development of a tool dedicated to low-fidelity interface prototyping that integrates artificial intelligence features and directly incorporates design methods, heuristics, and guidelines into its

[9]https://mockflow.com
[10]https://wireframe.cc
[11]https://www.mockplus.com
[12]https://www.flinto.com

structure. Such a tool could offer more effective support to professionals in the field, promoting the creation of higher-quality prototypes aligned with end-users' needs.

This study's main contribution is providing a comprehensive and up-to-date overview of the ecosystem of tools for low-fidelity prototyping. The systematization conducted not only allows for a clearer understanding of the limitations of current solutions but also provides relevant insights for future research and more informed decision-making in academic and professional contexts.

Ethical Considerations

This study did not involve any direct intervention with human participants, as its nature is exclusively bibliographic and analytical.

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