Keynote CENTRIC 2024

AI and the Future of User-Centered Design: Insights from UX Research and Evaluation

CAEBUS Center for Advanced E-Business Studies
Prof. Dr. Stephan Böhm

October 1st, 2024

RHEINMAIN UNIVERSITY OF APPLIED SCIENCES

A mid-sized German university located close to Frankfurt/Main

RheinMain University of Applied Sciences

- Founded in 1971 as a University of Applied Sciences
- Campus in Wiesbaden and Rüsselsheim
- ca. 13,000 students
- ca. 1,000 employees, > 250 professors
- Undergraduate and graduate programs: Bachelor, Master, PhD
- No tuition fees for German and international students
- Practice-driven education and applied research
- Five faculties with diverse academic areas
  - Design, Computer Sciences, Media (DCSM)
  - Wiesbaden Business School
  - Architecture & Civil Engineering
  - Engineering
  - Applied Social Sciences

THE FEDERAL STATE OF HESSE

Economic powerhouse in the heart of Germany

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- Approx. 6.3 million residents
- Capital: Wiesbaden
- Largest city: Frankfurt am Main
- Hesse's economic powerhouse:
  the Rhine-Main area
- High diversity: from modern cities to picturesque villages
- Beautiful landscapes along the two big rivers

THE CAEBUS TEAM

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Founded in 2014, the CAEBUS Center of Advanced E-Business Research focusses on research fields in areas related of **digitalization** and **e-business**

Prof. Dr. Stephan Böhm
Telecommunication & Mobile Media

Prof. Dr. Peter Winzer
Telecommunications, Media Economics & Controlling

CAEBUS
Center for Advanced E-Business Studies

Stefan Graser (MSc)

User Experience of Augmented Reality

Paul Heß (MSc)

AI-based Media Disruption

Jasmin Ebert (MA)

Pricing for Innovative Mobile Services

RESEARCH FOCUS STEPHAN BÖHM

Research on innovative interactive media/digital business technologies

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More than 100 articles and presentations
Selected work can be found here:
https://www.hs-rm.de/de/hochschule/personen/boehm-stephan

Research Areas

Technology

User/ Applications

1. **Technical Feasibility?** ← **Prototyping/Trials**
2. **Industry Impact?** ← **Market/Expert Surveys**
3. **User Acceptance/UX?** ← **Acceptance & UX Research**

AGENDA

1. Introduction and Background on UX and UCD
2. AI and User-Centered Mobile App Design
3. A Glimpse on the Status Quo in Practice (Demo)
4. Some Current Research Examples
5. Conclusions and Outlook

USER-CENTERED DESIGN (UCD) PROCESS

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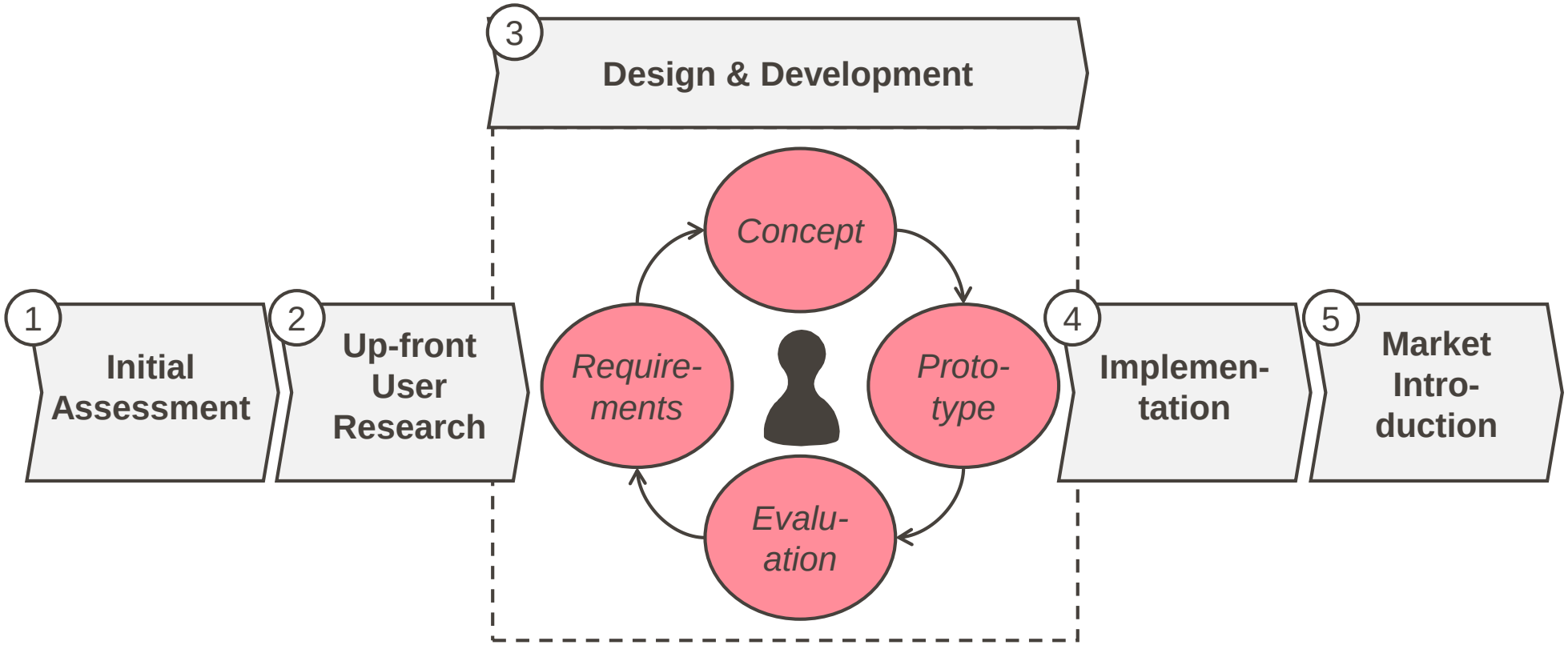
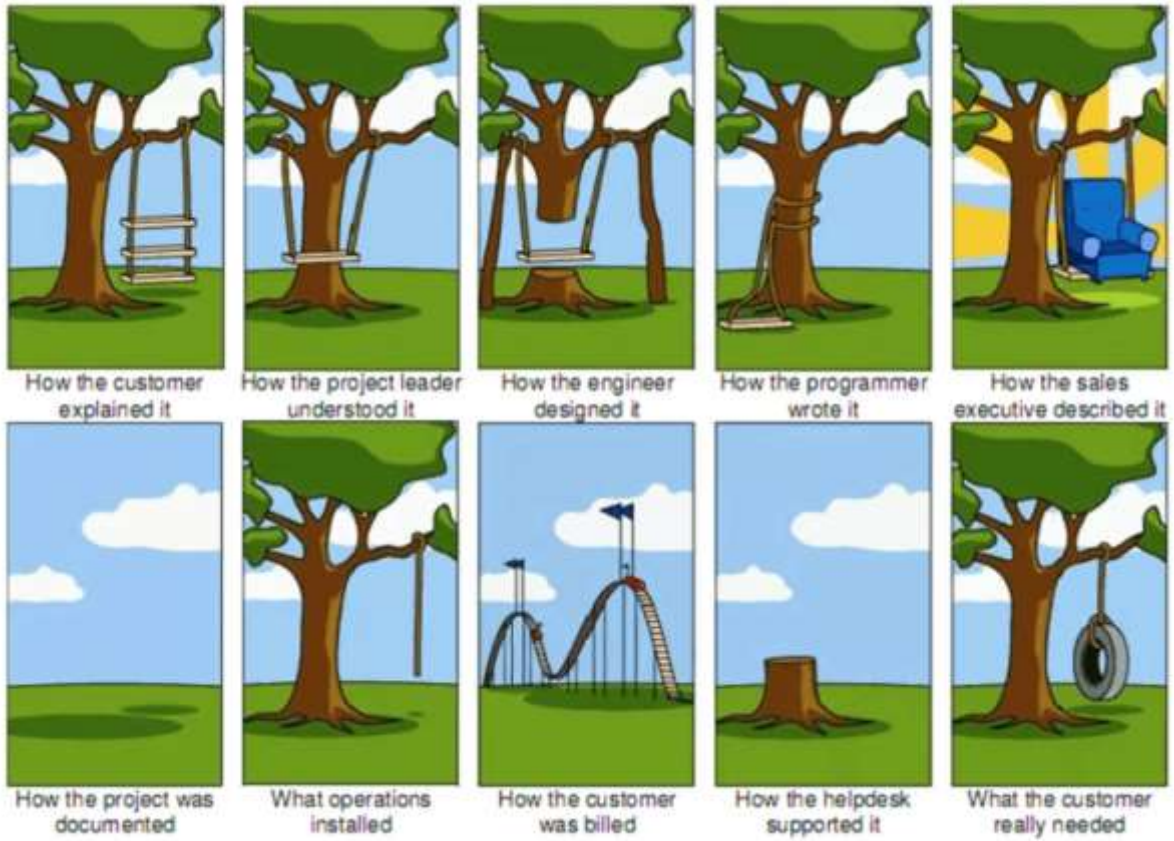
- User-Centered Design (UCD) integrates user feedback early in the development.
- Prototypes are created to represent the app's version/concept and gather user insights.
- An up-front phase involves experts defining the app's concept and core features.



IDEA OF PRODUCT ITERATION

UCD aims to bridge the information gap between users and developers through an iterative process with systematic evaluation of user feedback



- Developers often lack information about customer requirements and expectations.
- Customers may also be unclear about what to expect from the final product and what's technically feasible.
- Therefore, in UCD, expectations and products are aligned iteratively through concept improvements driven by user feedback.

Picture source: https://medium.com/@veenathangavel/customers-always-buy-what-they-think-they-want-58c3298f0a59

PARADIGM CHANGE

The UCD approach changes software design from linear to iterative

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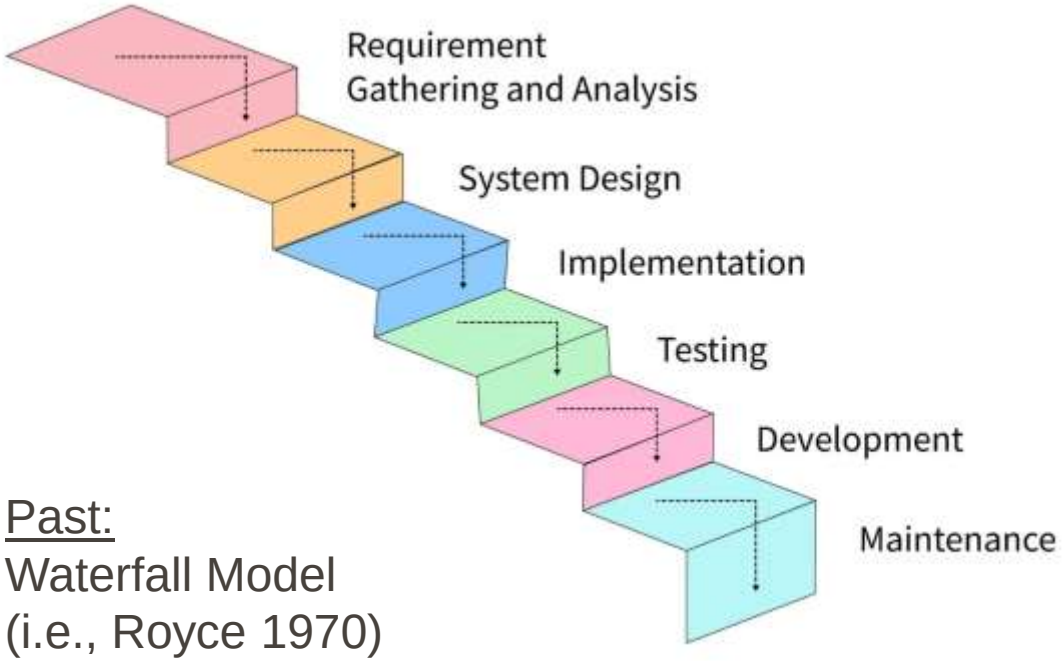
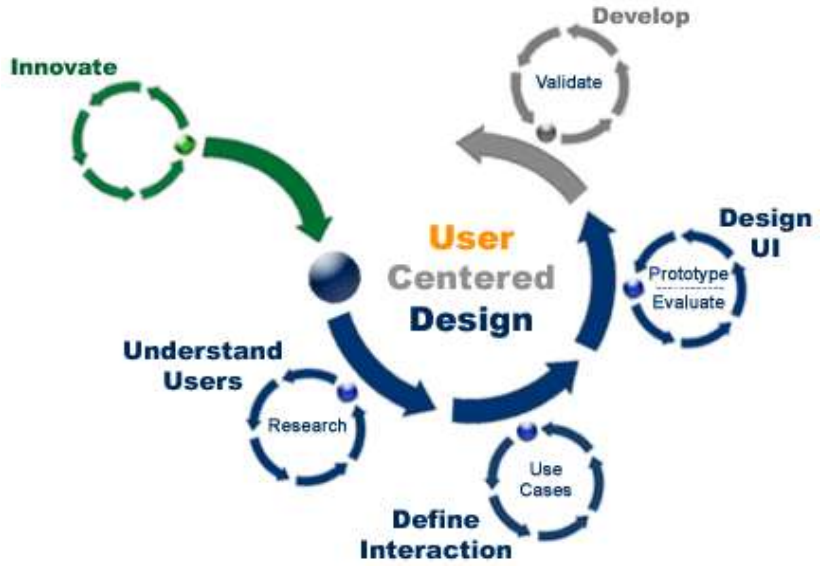


<u>Past:</u>
Waterfall Model
(i.e., Royce 1970)



<u>Today:</u>
User-Centered Design
(i.e., ISO 9241, SAP)

Source of pictures: https://miro.medium.com/v2/resize:fit:4800/format:webp/1*k66hoz5Y_9DId_a3UrgIpA.jpeg, http://www.sapdesignguild.org/editions/edition10/ucd_overview.asp

UP-FRONT USER VS USABILITY RESEARCH

The UCD process starts fast and iterates based on user feedback.

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- Unlike the waterfall model, UCD reduces the requirements analysis to the identification of a minimal viable product (MVP) in an upfront user research phase.
- The goal is to understand the key user requirements and define a product definition statement that takes into account user needs and existing solutions in the competitive environment.

Up-front user research: Informs product requirements and design

"What should we design?"

Usability testing: After requirements defined and initial design established

"Did we design it right?"

Source: Ginsburg 2010

USER EXPERIENCE (UX)

While usability focuses on system interaction, UX takes a more holistic view of the user's experiences and impressions from using a system

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ISO 9241-210:2010(en)
Ergonomics of human-system interaction — Part 210: Human-centred design for interactive systems

2.15

user experience

person's perceptions and responses resulting from the use and/or anticipated use of a product, system or service

Note 1 to entry: User experience includes all the users' emotions, beliefs, preferences, perceptions, physical and psychological responses, behaviours and accomplishments that occur before, during and after use.

Note 2 to entry: User experience is a consequence of brand image, presentation, functionality, system performance, interactive behaviour and assistive capabilities of the interactive system, the user's internal and physical state resulting from prior experiences, attitudes, skills and personality, and the context of use.

Note 3 to entry: Usability, when interpreted from the perspective of the users' personal goals, can include the kind of perceptual and emotional aspects typically associated with user experience . Usability criteria can be used to assess aspects of user experience .

Source: https://www.iso.org/obp/ui/#iso:std:iso:9241:-210:ed-1:v1:en

UX VS USABILITY

The ultimate goal of UX engineering is to create a product that is easy to use, desirable and contributes to a positive brand experience

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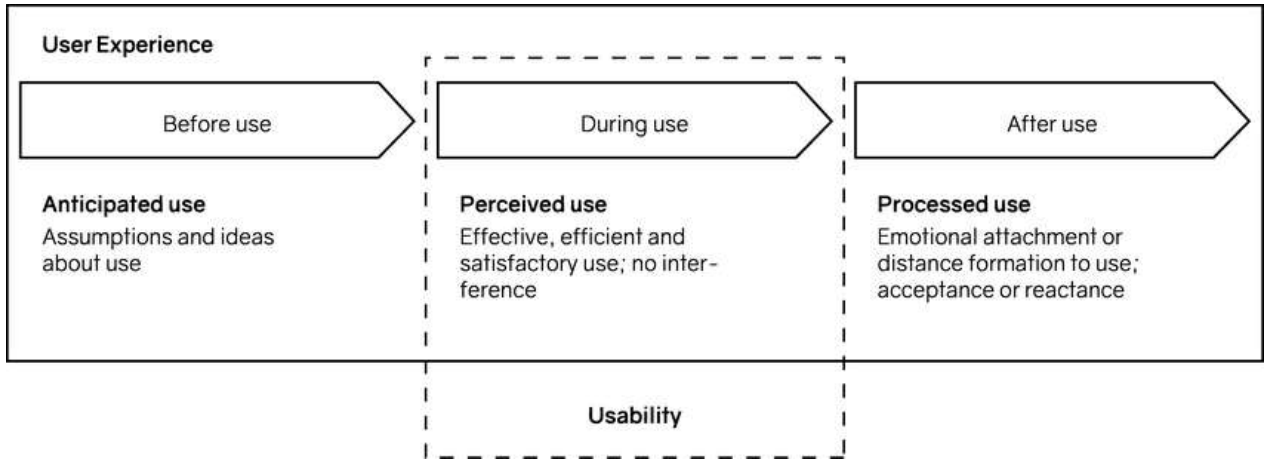
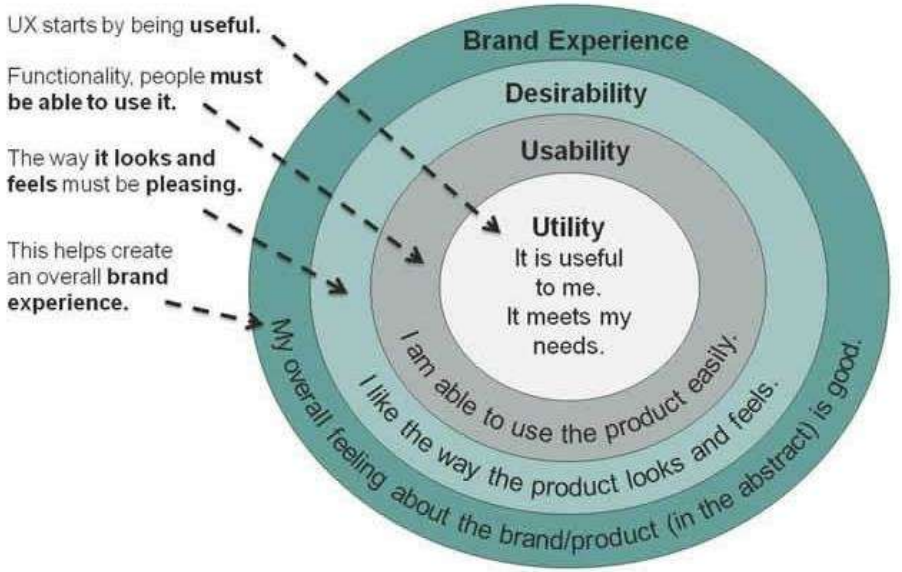
Usability and UX from the perspective of ISO 9241



User Experience (NNGroup, 2008)



Picture Sources: Boberg 2018 (https://www.researchgate.net/publication/326735386_ENTERPRISE_EXPERIENCE_Experience_Design_as_Business_Strategy_-_A_Case_Study), Bernhard 2020 (https://www.researchgate.net/figure/Relationship-of-Usability-and-UX-from-the-perspective-of-ISO-9241-ProContext-2010_fig2_348235764)

RESEARCH ON UX AND AI

UX and AI have gained importance as research topics in recent years

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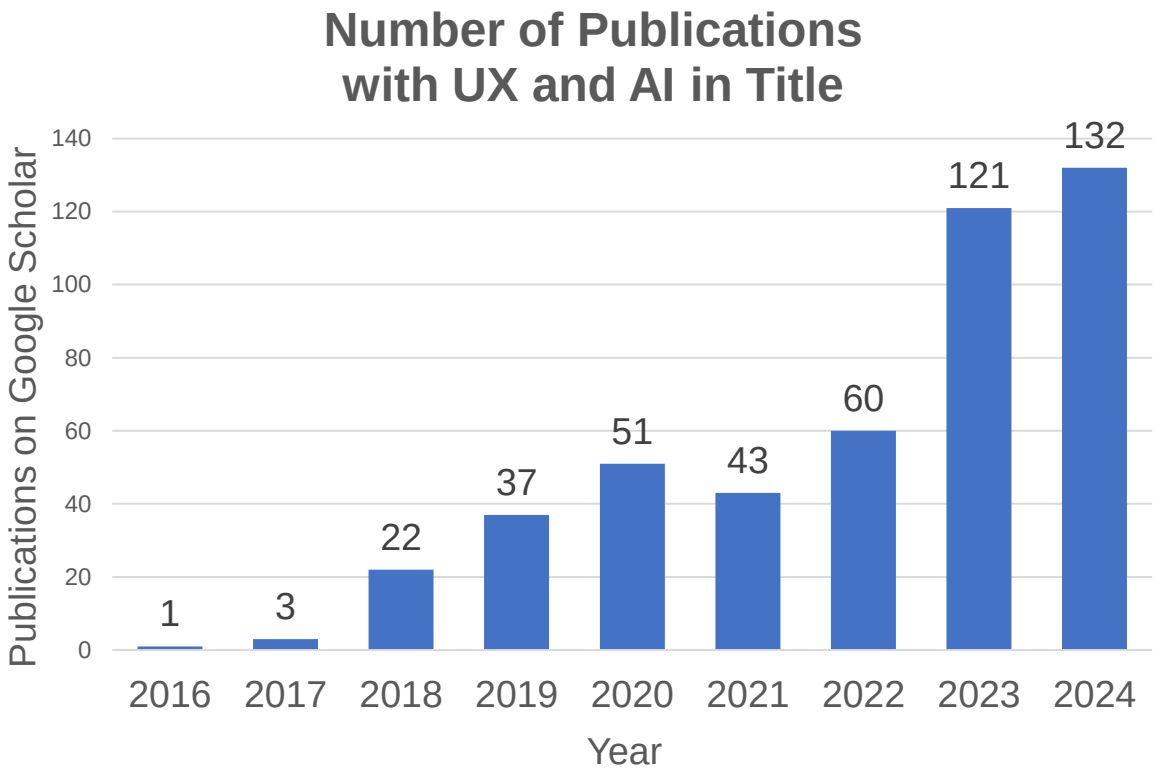

- The study of UX aspects in connection with AI is still a relatively new field of research.
- Research perspectives are (1) UX of AI applications and (2) the use of AI for UX research – (2) is discussed here.
- The aspects mentioned above are not differentiated in the figure on the left.
- However, since 2018 UX/AI research activities are growing rapidly.

Source: Google Scholar [allintitle: ("Artificial Intelligence" OR AI) ("User Experience" OR UX], UX/AI research activities have grown

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EXAMPLE: UCD FOR MOBILE APP DEVELOPMENT

App development extensively uses UCD due to the often rather small/short projects, high competition, and high market dynamics

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Success Story Mobile Apps

- Essential for device personalization.
- App stores launched ~15 years ago transformed the software market.

Large Market and Intense Competition (as of Oct 2023) [1]

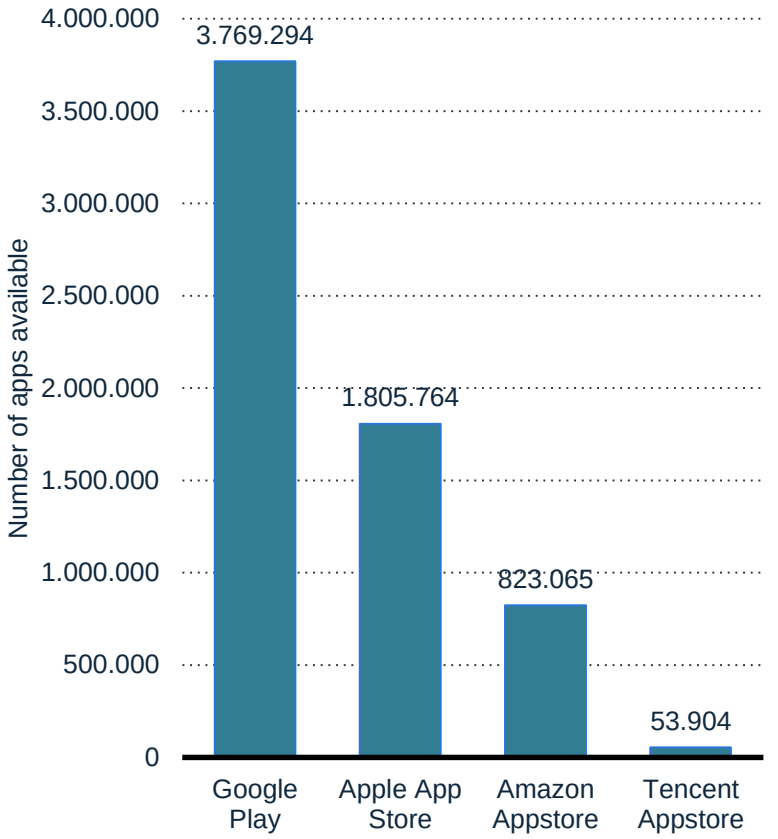
- Google Play Store: ~3.8 million apps, Apple App Store: ~1.8 million apps.
- Dominated by small companies; many apps are free or low-cost.
- Revenue models are often ad-based.

Need for Customer Centricity and Prototyping [2][3][4][5]

- Emphasis on rapid prototyping, Scrum, and User Centered Design.
- UCD prioritizes early user involvement for feedback.
- Prototypes used in iterative feedback cycles to align with user needs.

Large Variety of Prototyping Tools and Techniques

- Evolved prototyping tools support collaboration and idea refinement.
- Enable presenting prototypes to test users for iterative feedback.



Source: [1]

METHODS FOR UP-FRONT USER RESEARCH

A variety of tools are available to conduct up-front user research and to document user feedback in the UCD process

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User Research Methods:
Shadowing (Context Analysis), Field Interviews, Diary Studies

User Research Analysis & Documentation:
Personas, Scenarios, Use Cases, User Journeys

Source of pictures: http://www.facit-digital.com, http://www.system-concepts.com, Suzanne Ginsburg 2010

PROTOTYPING TOOLS

When testing UX and usability during development, the use of app prototypes with increasing fidelity is of great importances

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Low-fidelity/Paper Prototypes
(e.g. Forms, Stencils)

High-fidelity/Click-Prototypes
(e.g. Axure)

Low-fidelity Prototypes/Wireframes
(e.g. Balsamiq)

Source of pictures: http://uxpin.com/mobile-kit-for-iphone.html, http://www.uistencils.com/products/iphone-stencil-kit, http://builds.balsamiq.com/b/mockups-web-demo/ , http://www.axure.com/learn/iphone-app/template

POTENTIAL AREAS OF AI-SUPPORT (1/2)

The integration of AI offers new potential for increasing efficiency throughout the entire UCD process and in UX evaluations.

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Comprehensive exploratory web and literature research has been conducted in Böhm/Graser 2023 [13] to identify areas of AI support for mobile app prototyping.

The following seven (potential) areas of AI-based app prototyping have been identified:

(1) **Idea Generation and Concept Definition**: In the initial phase, problems and value propositions are defined to form a product statement with Generative AI like ChatGPT aiding in developing ideas and functionalities.

(2) **Concept Customization and Refinement**: App concepts are refined based on user feedback and target group needs, with Generative AI streamlining the editing process and adapting concepts for specific audiences.

(3) **Automated Design and Mock-up Generation**: After conceptual textual phases, visual prototyping begins, supported by Generative AI to break down functionalities and select, combine, and design UI elements for an efficient user experience.

POTENTIAL AREAS OF AI-SUPPORT (2/2)

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(4) **Generation of Sample Content and Design Variations**: Generative AI can efficiently produce content for prototypes, moving from low to high fidelity while considering user feedback without making early detail level a distraction.

(5) **Automated Testing and User Behavior Prediction:** AI assists in creating test scenarios and predicting user behavior to streamline the testing process and identify the best design elements.

(6) **Automated Evaluation of User Feedback and Refinements:** AI, particularly LLMs, processes and analyzes large amounts of user feedback data, identifying key issues and summarizing user experiences.

(7) **Implementation of Prototypes and Text-to-code Automation:** AI-based text-to-code methods help transition from visual prototyping to functional app development, especially for apps with complex real-world interactions.

PROTOTYPE DEFINITION AND VARIANTS

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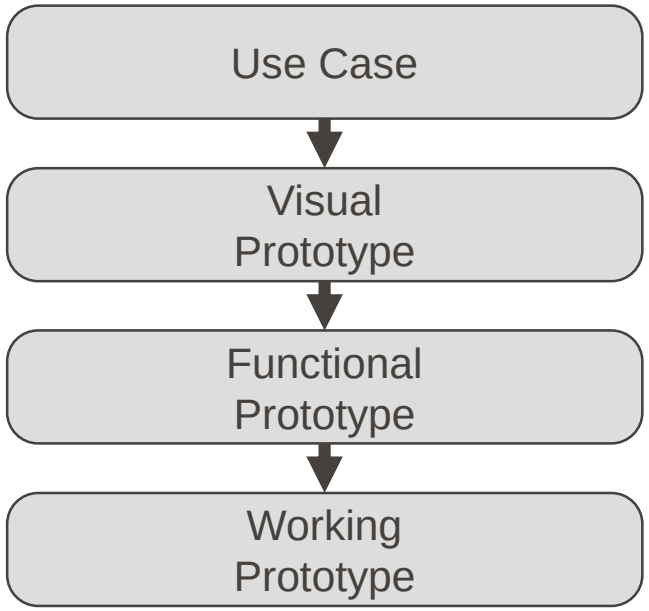
The **term prototype** in software development refers to "an initial version of a software system that is used to demonstrate concepts, try out design options, and find out more about the problem and its possible solutions." (Sommerville 2011 [10], p. 45)



The basic concept with a textual or formal description of the intended user interaction and system's behavior.

(Interactive) concept visualisation that simulates system behavior at GUI level to demonstrate the concept to the user.

Concept representation with (partly) implemented system functions to support testing of actual system behavior.

Representation of the concept close to the final product that allows field testing in real-world scenarios.

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AI FOR PROTOTYPE GENERATION

A wide range of AI-supported prototyping solutions for mobile apps are now available – some have been analyzed in Böhm/Graser 2023 [13]

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Figma is a popular platform for mobile app prototyping characterized by open interfaces and a market with many plug-ins [11]. AI-based prototyping is available by tools like Wireframe Designer.

appypie

uizard

Mockitt

Appy Pie [7], Uizard [8], and Mockitt [9] are examples of emerging integrated AI-based prototyping solutions emphasizing AI support in their marketing effort.

CHATGPT

In the area of prototyping support through general Generative AI, ChatGPT [6] can be used to generate code-based prototypes [12].

DEMO: UIZARD FOR PROTOTYPE GENERATION (1/4)

Using Uizard for AI-supported prototype generation

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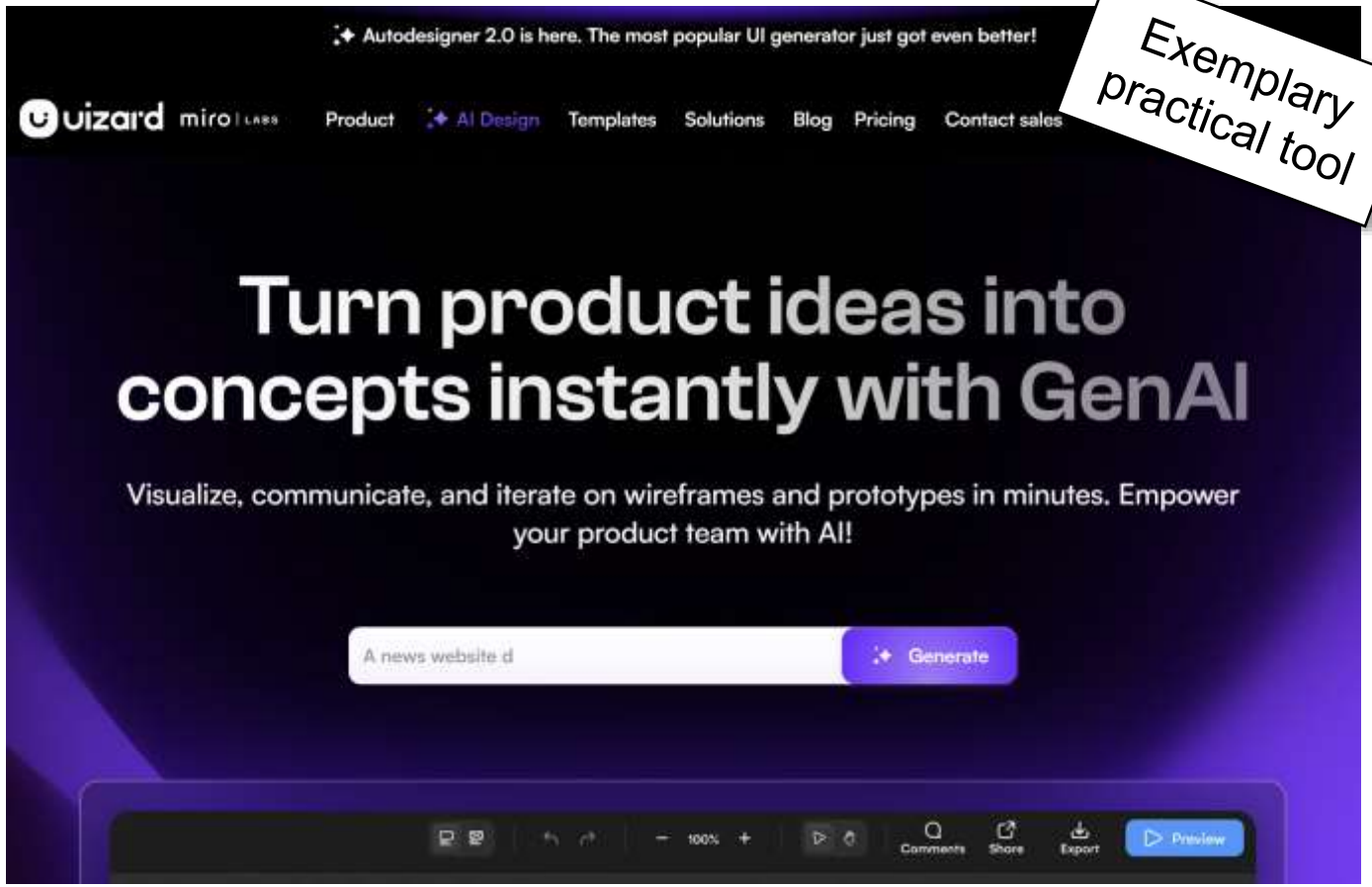
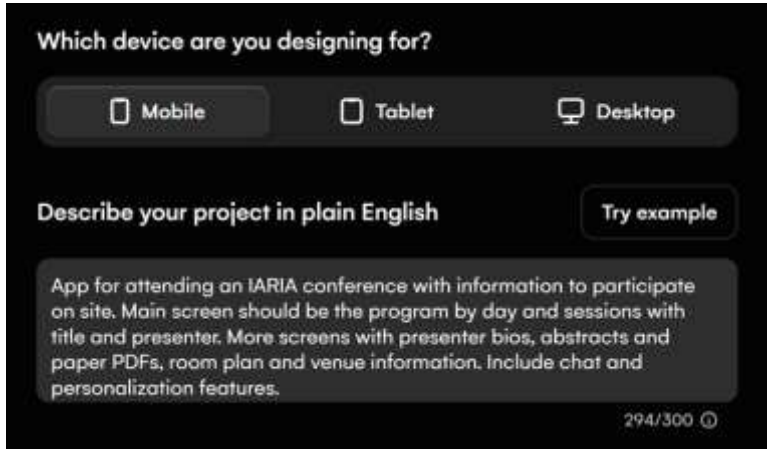
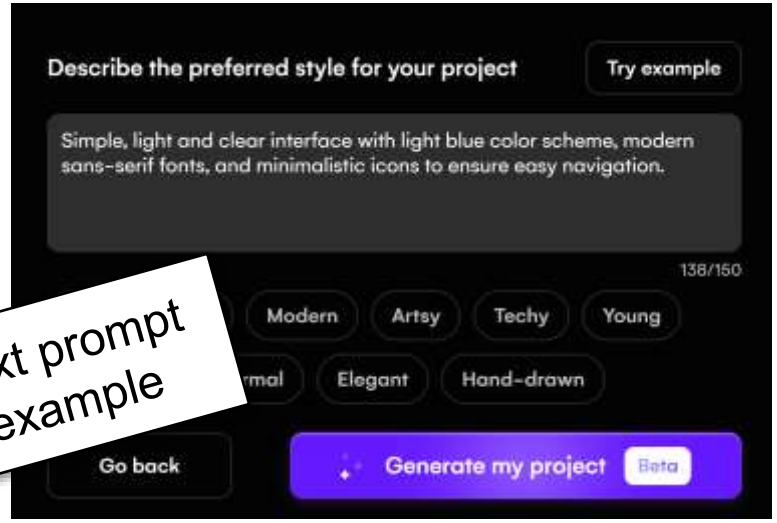


Exemplary practical tool





Text prompt example

https://uizard.io/

DEMO: UIZARD FOR PROTOTYPE GENERATION (2/4)

A simple interactive app prototype is created as a result of the prompts, which can be further developed and exported

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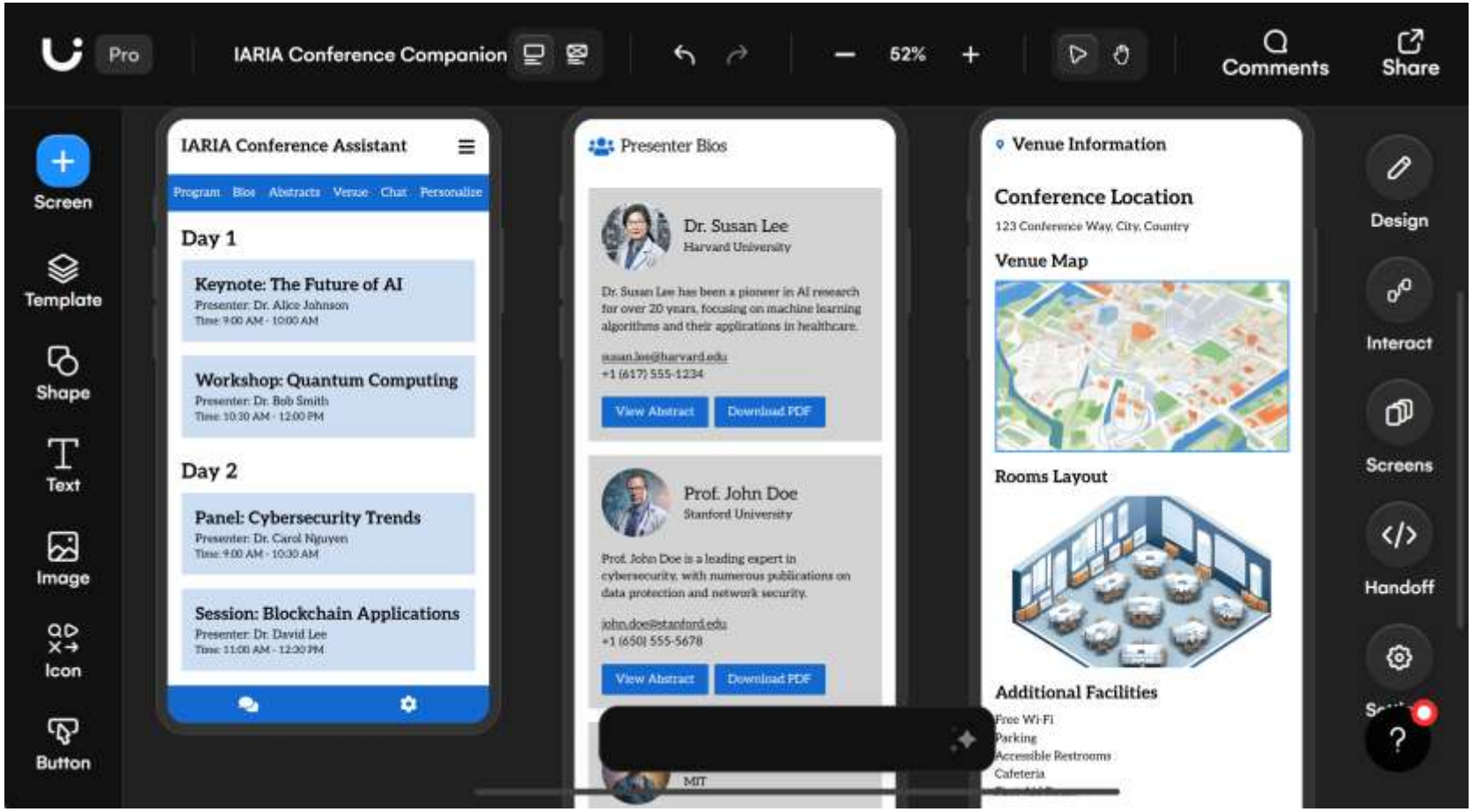

DEMO: UIZARD FOR PROTOTYPE GENERATION (3/4)

Uizard includes a function that uses AI to predict a heat map for attention distribution on selected screens

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DEMO: UIZARD FOR PROTOTYPE GENERATION (4/4)

Uizard can also provide an AI-based evaluation for individual screens and suggest improvements

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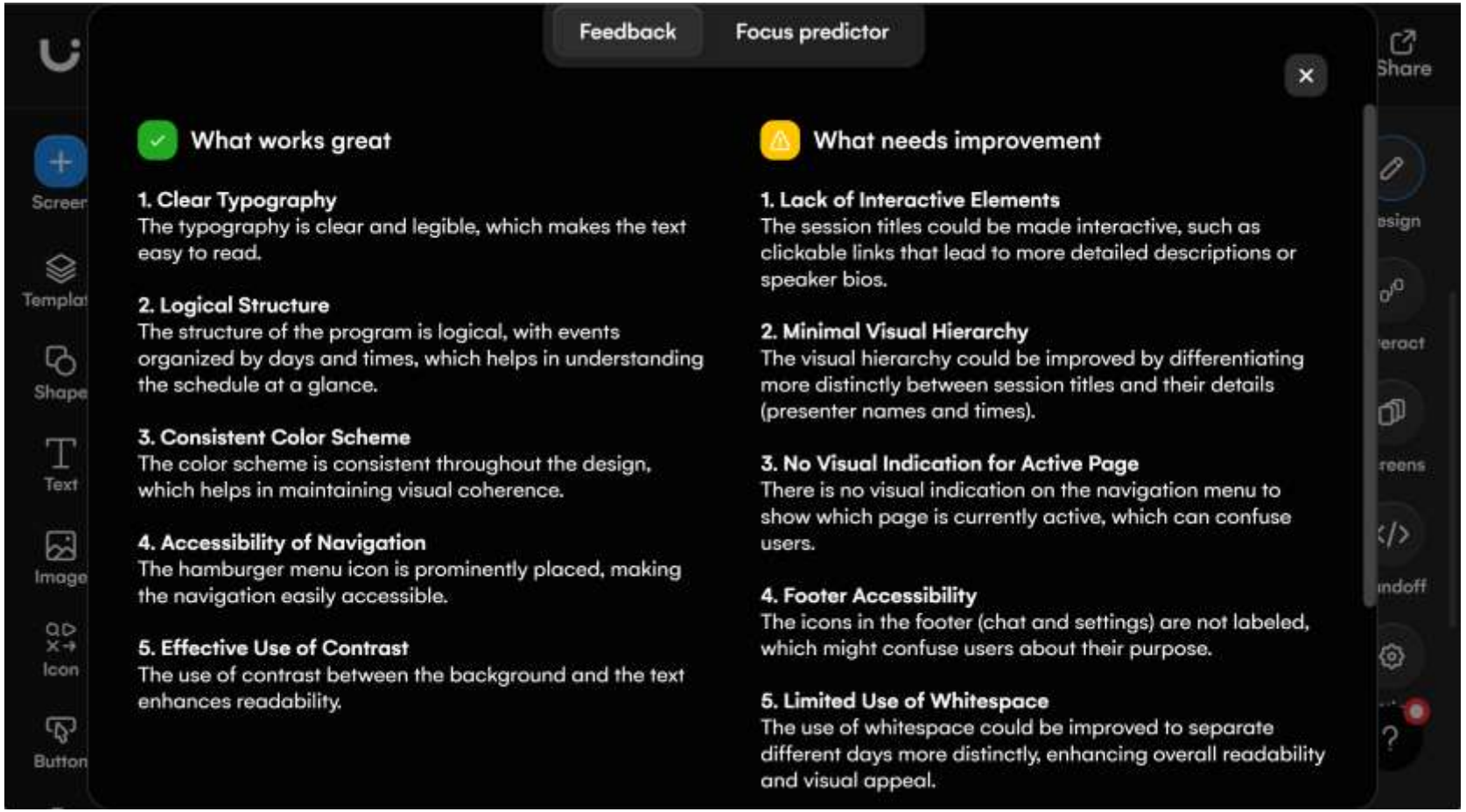

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CURRENT RESEARCH EXAMPLES

Our team has already conducted various research projects to investigate the application potential of AI in UX and UCD processes

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Selected research examples are …

(1) **UX Factor Extraction:** Use of Generative AI to extract common (semantic similar) UX dimensions from a set of established UX questionnaires and measurement models.

(2) **AI-supported Prototyping:** Analysis of the status quo for the applicability of AI-based prototyping solutions for app development.

(3) **AI in UX Evaluation Scenarios:** Use of Generative AI to evaluate Thinking Aloud protocols based on given UX dimensions and items and to extract user statements.

UX FACTOR EXTRACTION (1/2)

Extraction of common UX items based on the semantic similarity

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Graser, S., Böhm, S., Schrepp, M. (2023), Using ChatGPT-4 for the Identification of Common UX Factors within a Pool of Measurement Items from Established UX Questionnaires, CENTRIC 2023, Valencia, Spain, 19–28.

Research Questions

- Can common UX factors be identified within the pooled items of widespread UX questionnaires?
- Can ChatGPT/an LLM be used to determine universal UX factors based on semantic similarities?

Approach

- Extraction of UX measurement items from 19 established UX questionnaires.
- Clustering of semantic similar items into topics
- Review of generated results based on existing UX factors from established questionnaires.

Evaluation results

- ChatGPT generated six main UX topics and 14 UX sub-topics based on the semantic similarity of the UX items.
- UX main topics extracted by ChatGPT were in line with the universal UX factors identified by Schrepp et al. (2023) in a meta-study.

UX FACTOR EXTRACTION (2/2)

Comparison of AI-generated topics and exisiting UX factors

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	Existing UX factors	AI-generated topics
(1)	Perspicuity	Ease of Use—Learning Curve
(2)	Efficiency	Efficiency and Speed
(3)	Dependability	Consistency and Integration
(4)	Usefulness	Functionality and Flexibility—Relevance and Utility
(5)	Intuitive use	Ease of Use
(6)	Adaptability	Adaptability
(7)	Novelty	-
(8)	Stimulation	Engagement Level
(9)	Clarity	Clarity and Understandability
(10)	Quality of Content	Relevance and Utility
(11)	Immersion	Engagement Level
(12)	Aesthetics	Aesthetics and Design—Aesthetics and Design
(13)	Identity	-
(14)	Loyalty	Loyalty
(15)	Trust	Trust and Security
(16)	Value	Perceived value

- 19 general purpose UX questionnaires were identified by an extensive literature research.
- A pool of 706 UX measurement items was extracted from the questionnairs.
- ChatGPT was prompted to group the items in the pool based on semantic similarity.
- ChatGPT provided 14 AI-generated UX topics shown in the table to the left.
- The AI-generated topics could be associated with common UX factors identified in a meta study by Schrepp et al. (2023)

AI-SUPPORTED PROTOTYPING (1/2)

Case study analysis of AI-based mobile app prototyping

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Böhm, S.; Graser, S. (2023). AI-based Mobile App Prototyping: Status Quo, Perspectives and Preliminary Insights from Experimental Case Studies. In CENTRIC 2023 : The Sixteenth International Conference on Advances in Human-oriented and Personalized Mechanisms, Technologies, and Services, Valencia, Spain, 29–37.

Research Questions

- What is the status quo of AI-support solutions in practice for mobile app prototyping?
- Can existing AI-support alternatives by clustered in a taxonomy of AI tools?
- Is the quality of prototyping results sufficient for productive use in UCD?

Approach

- Industry study to identify existing AI-based mobile app prototyping tools.
- Testing of prototyping tasks with AI-plugins, integrated solutions and general Generative AI.
- Initial evaluation of the quality of the results and the workflow impact of existing solutions.

Research Results

- Tools generate impressive but simple prototypes with standardized design patterns – sometimes with rather random artifacts.
- Tools provide a jumpstart on prototyping but still require extensive human refinements and revisions.

AI-SUPPORTED PROTOTYPING (2/2)

Visual prototypes were generated by a single prompt, while functional, code-based prototypes required comprehensive iterations for bug-fixing

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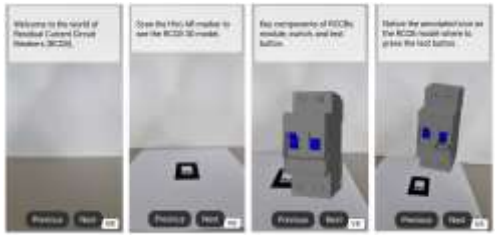

- All visual prototyping tools generated several interactively linked app screens based on a single prompt.
- The prototypes produced differed in detail. Some tools produced generic content, such as selection menus or login screens.
- The design quality varied significantly, but all prototypes offered options to further develop and improve the prompting results by hand.
- The most time-consuming approach was code-based prototyping with ChatGPT – however, a functional AR application could be developed by debugging and improving the generated code.

AI IN UX EVALUATION SCENARIOS (1/2)

Integration of GenAI to support UX testings and systematic thinking aloud transcripts analysis by UX factors

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Graser, S., Snimshchikova, A., Schrepp, M., Böhm, S. (2024), Enhancing UX Research Activities Using GenAI – Potential Applications and Challenges, CENTRIC 2024, Venice, Italy, 1–13.

Research Questions

- Can GenAI/ChatGPT be used to extract useful user statements from thinking-aloud transcripts?
- How is the frequency of extracted user statements related to quantitatively determined UX scores?

Approach

- Evaluation of user expectations and experience by established UX questionnaires.
- Correlation analysis with qualitative (UX scores) and quantitative (frequency of statements) results.

Evaluation results

- ChatGPT was productive in analyzing the thinking-aloud transcripts and extracting user comments to support quantitative results.
- A relationship was found between the quantitatively identified UX deficits and the frequency of supporting user statements for affected UX factors.

AI IN UX EVALUATION SCENARIOS (2/2)

Analysis of qualitative (frequency) and quantitative (UX scores) results

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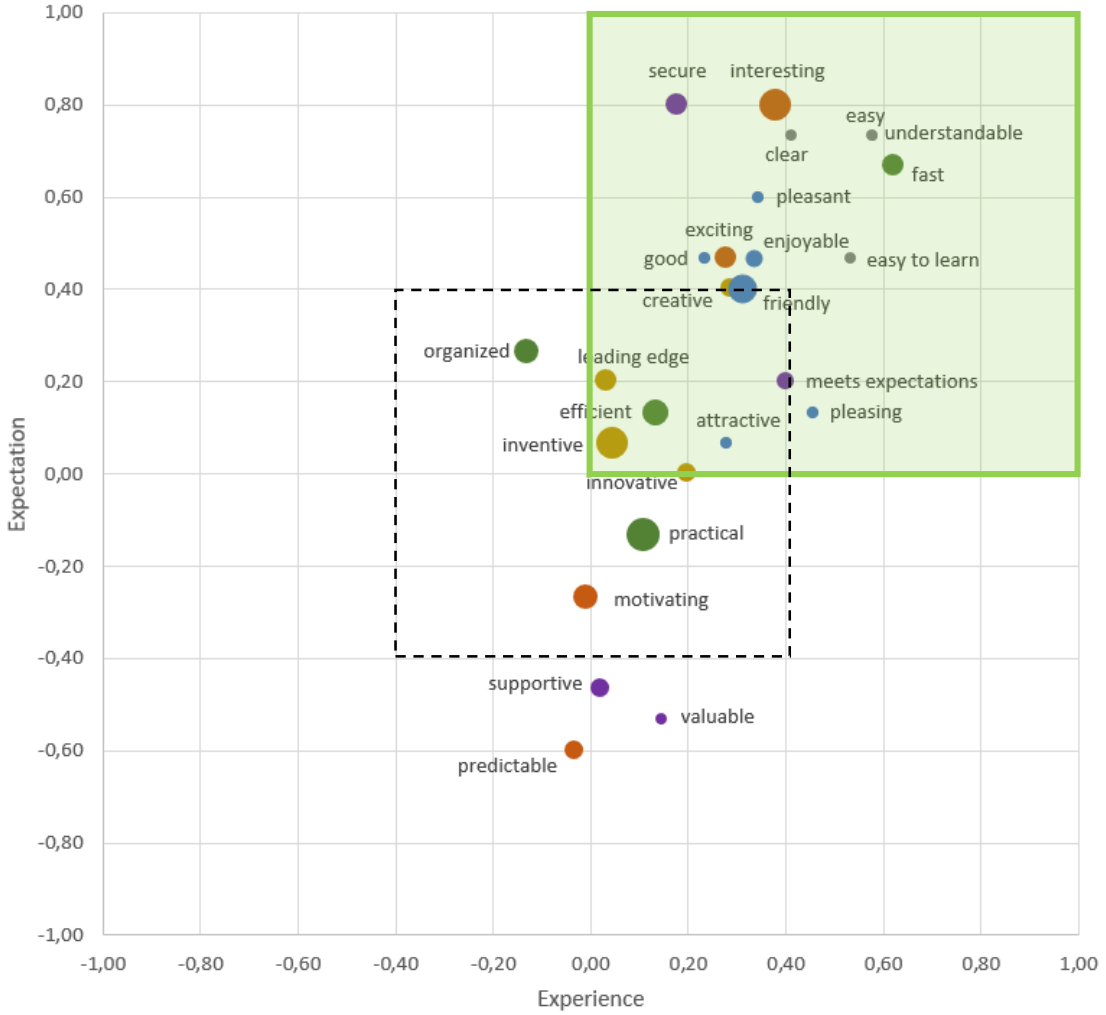

- User expectations (pre-testing, UEEE) and experiences (post-testing, UEQ) were measured using established UX questionnaires.
- Assessment was carried out using semantic differentials – a value +1 (-1) means that the attribute expressed by the adjective was expected/perceived using the system (or not).
- Pre-test, post-test (scores) results and number of extracted statements (size of dots) are shown in the diagram on the left.
- Overall, the results indicated positive expectations confirmed by the experience (green box).
- However, there were many statements with rather indifferent expectations and experiences (dotted box) where statements provide valuable insights.

PROJECTS (1/2)

Development and UX evaluation of MAR-based learning prototype

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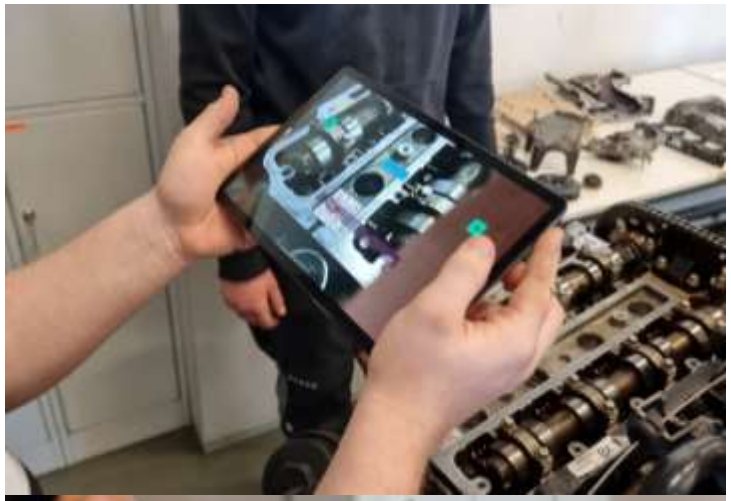
Graser, S., Böhm, S., Berger, L. (2023). Measuring the User Experience of Mobile Augmented Reality: A Comparative Analysis based on a Prototype in Corporate Learning, IWEMB 2022.

Approach

- Development of a marker-based MAR prototype with Unity and Vuforia. Implementation of a handheld AR application to support the learning process of changing a timing chain in a car engine for car mechanics apprentices in cooperation with the Chamber of Handicrafts in Wiesbaden
- Quantitative UX evaluation using the SUS and UEQ questionnaires

Evaluation results

- The UX of the prototype was perceived as neutral until positive.
- The prototype was easy to understand and use; the interface was perceived as attractive (despite cumbersome QR code scans).
- Relatively neutral overall impression.



PROJECTS (2/2)

Development of AR-based learning prototype and evaluation of the UX and learning efficiency.

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Approach

- Development of a markerless AR prototype with Unity and Vuforia SDK
- Implement a head-mounted AR application to support the learning scenario for a drilling process on a milling machine.
- With plumbing, heating, and cooling apprentices in cooperation with the Chamber of Handicrafts in Wiesbaden.
- Quantitative UX evaluation using the UEQ questionnaire.
- Evaluation of the learning efficiency (motivation and memory retention) by applying the IMMS* and short-test.

Evaluation results

- The UX was perceved neutral to positive.
- Students expressed higher motivation to learning with AR in comparison to paper-based instructions.
- However, paper-based instructions lead to higher memory retention.

**Instructional Materials Motivation Survey*

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CONCLUSIONS & OUTLOOK

AI can be used in many areas of UCD and UX engineering to increase the efficiency of processes

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- Generative AI can efficiently automate the recognition and reproduction of proven patterns (for content generation and analysis) in UCD and UX engineering.
- Generative AI can achieve efficiency gains in software artifact creation and evaluation, particularly for standard tasks with a low level of innovativeness and creativity.
- The problem, however, is the “black box” character of Generative AI solutions; the logic behind the content generation and evaluation cannot be explained or understood.
- Moreover, if user feedback is replaced by AI evaluation, corresponding AI tools may undermine the actual goal of user-centered design.
- Therefore, research that explicitly examines the reliability, validity, and limits of AI-based designs and evaluations compared to human approaches is urgently needed.

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